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WEEKLY 28 November 2015

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Cover image
Edward Kinsella

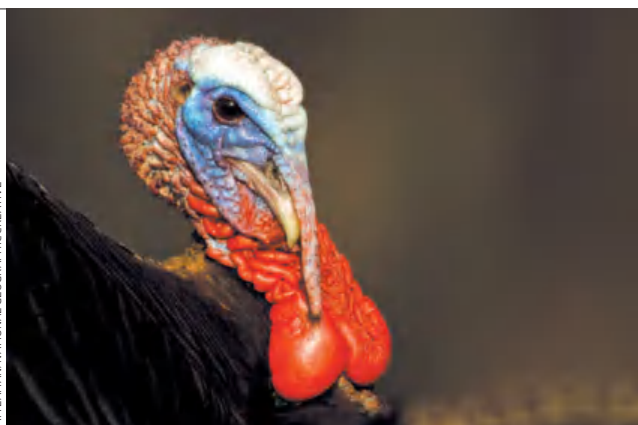
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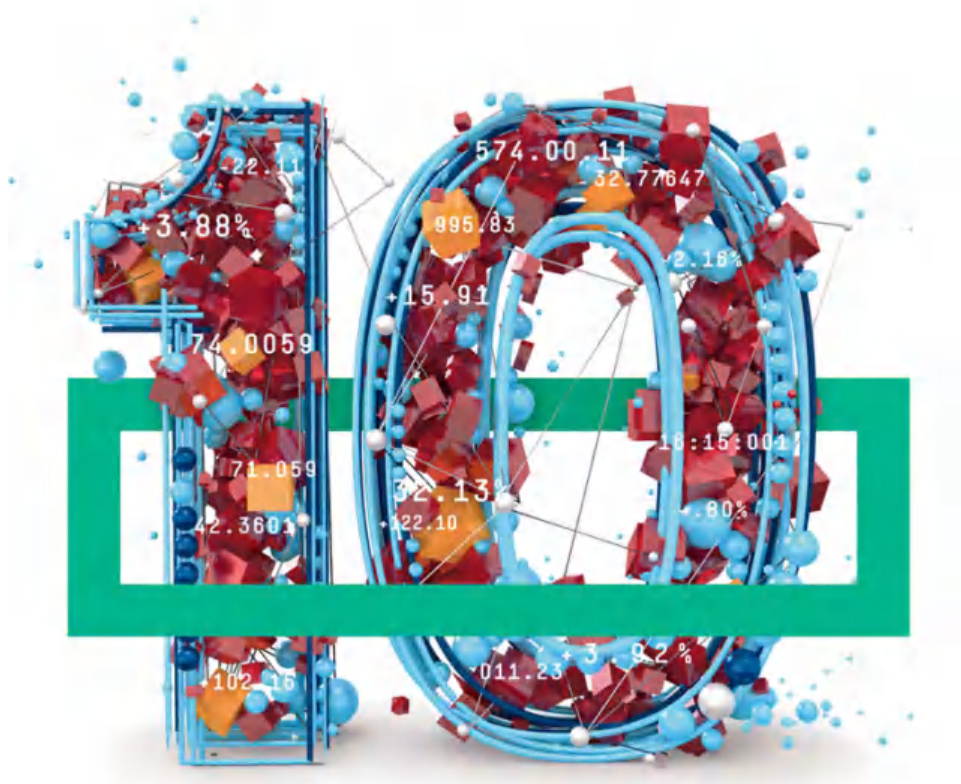
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A good deal, not any deal

Mediocrity must not triumph at the Paris climate summit

IS IT too late to prevent climate disaster? Many believe next week's summit in Paris represents our last real chance to avoid it. The global surface temperature has already risen by 1 °C – halfway to the somewhat arbitrary but generally accepted 2 °C threshold of “dangerous” warming.

Thus the widespread sense of determination to do whatever it takes to strike a deal. This zeal is understandable, given the dismal failure of the 2009 summit in Copenhagen. With six years of lost time to make up, no widely ratified extension of the Kyoto Protocol and disheartening data coming in thick and fast, the future looks bleak if meaningful action is not taken soon. There are grounds for hope that Paris will yield such action – but also reason to doubt it will (see page 10).

If there is comfort to be had, it's in the old saw that where there's a will, there's a way. There are many ways to tackle climate change – ranging from reducing emissions to sequestering carbon dioxide to geoengineering – and more are emerging all the time. But none is a solution by itself, most are technologically immature, and many will need strong backing if they are to be scaled up fast enough to make a difference – assuming they can be at all.

Is there the will? Ostensibly there is: this time round, most countries have already drawn up declarations of the emissions cuts they are prepared to make. But their pledges aren't enough to limit warming to 2 °C. Optimists say these can be “ratcheted up” to more ambitious targets during the course of any Paris Protocol, which would run until 2030. But

“A weak deal would be dangerous because it would achieve little but instil complacency”

as it is, even the initial agreement may not be legally binding.

Is it plausible that countries will voluntarily rein in emissions? The world's biggest emitter, China, has belched out even more carbon than expected – but has also taken an unexpectedly strong stance on cutting back, prompted by its own air pollution problems. To be sure, its rulers have an advantage over their democratic counterparts elsewhere: they simply change the rules by fiat (see page 40). Hopes are high that China will take a leading role in Paris.

Will others join them? The severity of climate risk is now well understood, with refuseniks like the US and Australia starting to come in from the fug. Developing

countries, balking at the cost of slowing their emissions growth to tackle a problem largely created by industrialised nations, may be encouraged by the offer of \$100 billion a year in aid from 2020 – although not by rich nations' reluctance to pay so far.

If Paris produces a legally binding deal with any kind of ratcheting mechanism, it is likely to be hailed as a great success. Indeed, many will hail *any* deal as a success. But a weak deal would be dangerous: it would achieve little but instil complacency.

A genuinely successful deal would deliver rapid emissions cuts, not vague promises or “reductions” that exist only as sleights of hand. It would provide real incentives for countries, companies and consumers to rationalise energy use; opening the door to a global carbon price would help. And it would put the world's collective will behind ways to ameliorate the causes and effects of climate change.

We cannot afford a triumph of mediocrity in Paris. We need a good deal; no, a very good deal. If we don't get one, all bets are off. Some say failure at Copenhagen has spurred negotiators on to make progress this time. If that turns out to be wishful thinking, wishes may be all we have left. ■



Tuesdays rock!

Weekend birth risks

HOW important is a birthday?

Babies born in English hospitals at the weekend have a greater risk of dying than those born at any other time of week, suggests an analysis of 1.35 million births. Further work is needed to investigate what is causing the difference, say the study authors.

On weekdays, there were 6.5 deaths per 1000 deliveries, compared with 7.1 on a weekend day. There would be 770 fewer deaths per year if all babies were born on a Tuesday – the day with the lowest death rate (*BMJ*, DOI: 10.1136/bmj.h5774).

The analysis, carried out by a team at Imperial College London, comes as junior doctors in England voted to strike over changes to their contracts, aimed at increasing the number of weekend staff.

Health minister Jeremy Hunt has said that no junior doctor will see a pay cut after the contracts come into force next year. Although doctors will see a basic pay increase of 11 per cent, they claim some could be worse off because of proposed cuts to the number of hours classed as unsociable and thus attracting extra pay – such as on a Saturday.

The contracts were designed, in part, to make it cheaper to have more doctors working at weekends. Therefore, medics in the NHS are likely to find they are working more weekends without the extra pay they get under existing contracts. Doctors also claim that the contracts remove vital patient safeguards and limit pay progression. Three strikes are scheduled for December.

Malaria's nemesis

IT'S one in the eye for both Mendel and malaria.

Researchers have given malaria-resistant mosquitoes a gene that subverts Gregor Mendel's rules of classical genetic inheritance.

"Releasing these engineered mosquitoes into the wild could stop malaria transmission"

Like humans, mosquitoes usually only pass one copy of each gene on to each of their offspring.

But Anthony James at the University of California, Irvine, and his colleagues have used the CRISPR gene editing technique to create a "gene drive". This makes offspring carry two copies of a gene variant from one parent. It works by allowing an engineered gene – in this case, one that confers resistance to malaria – to insert a copy of itself into the corresponding chromosome inherited from the other parent.

This can make a specific version of a gene spread through a population much faster. The team

found that 99.5 per cent of offspring inherited the resistance gene when engineered mosquitoes bred with normal ones (*PNAS*, doi.org/9gq). This is double the best possible result by normal genetic inheritance. If such engineered mosquitoes were released into the wild, the resistance gene could stop malaria transmission.

But it's very early days for the technology, says Austin Burt at Imperial College London. "This gene drive approach has a lot of potential, but we're talking 10 to 15 years."

Catch a wave

LISTEN up: the hunt is on for ripples in space-time. On 2 December, a spacecraft will blast off from the European Space Agency's base in French Guiana, carrying equipment designed to help detect gravitational waves. These are thought to emanate from cosmic collisions, but are so faint that even the strongest sources are barely detectable at a distance.

The LISA Pathfinder mission will test the technology required to observe gravitational waves in

space for the first time. Einstein predicted that the movement of massive objects would change the curvature of space-time and produce such waves. But so far, none has been definitively detected.

LISA Pathfinder will consist of two gold-platinum cubes in free fall, with lasers tracking their slight motions. It will be a dress rehearsal for eLISA, a bigger mission set for 2034 that will have three such detectors arranged in a triangle. If a gravitational wave goes by, it should displace the cubes enough for us to tell.

Surprise launch

NOW delivering to the edge of space. The rocket company set up by Amazon founder Jeff Bezos successfully launched and landed an uncrewed rocket on Monday.

The New Shepard capsule and launch vehicle reached an altitude of about 100 kilometres before separating. The capsule deployed its parachutes and drifted to the ground, while the rocket used controlled firings to descend before deploying its landing legs



Perfect landing

for a triumphant return (see video at bit.ly/originrocket).

It is the second surprise test this year, following a launch in April. That time, a loss of hydraulic pressure meant Bezos's firm, Blue Origin, was not able to recover the rocket. The company has so far launched its capsules without a crew but is working towards a mission that will give six people 4 minutes of weightlessness and a view of Earth from space.

This latest success puts Blue Origin in direct competition with SpaceX, which is working to bring a craft back from orbit to land on a floating barge.

First GM fish is a go

WOULD you like chips with your genetically modified fish? The first GM meat may hit markets in two years, following last week's approval for a fast-growing GM salmon.

The fish is safe to eat, says the US Food and Drug Administration, and would not have a significant impact on the environment in the US – though that may be because it will be reared in confinement in Panama. Labelling it as GM will be optional.

The fish's future now depends on whether it fulfils its commercial promise to boost profit margins for farmers. Some US supermarkets have already said they will not stock it.

The fish is an Atlantic salmon modified with two bits of DNA. One is a gene for growth hormone, from the related Pacific Chinook salmon. It is inserted linked to DNA from a fish called the ocean pout. This DNA keeps the growth gene switched "on" all the time, instead of seasonally as in normal salmon.

As a result, the salmon grows faster, and needs less food to do so: the firm behind it, AquaBounty of Massachusetts, claims the fish grows twice as fast, and makes a gram of salmon flesh with 20 to 25 per cent less food.

Koala sex relief

FINALLY, some good news for Australia's favourite tree-hugging marsupials – neighbouring populations are interbreeding. Troubled by chlamydia and habitat destruction, some local populations have become critically endangered or even extinct, leaving conservationists concerned about inbreeding.

Herman Raadsma at the University of Sydney, Australia, and his colleagues sequenced the genomes of 171 koalas from eight regions along the east coast of Australia. This revealed that the

animals are happily breeding with neighbouring groups.

"The bottom line is it's not desperate," says Raadsma. He adds that the koalas should continue to interbreed as long as corridors link populations.

Because koalas from different parts of Australia appear quite distinct, some researchers have classified them into three separate subspecies – visibly varying populations that could interbreed but don't. Yet Raadsma has found more genetic diversity within than between these three groups (*Conservation Genetics*, doi.org/9gv).

Future is black for grey parrots

ALEX the pet African grey parrot became famous for his cleverness. Yet his wild kin may be in trouble because of the pet trade, along with deforestation, especially of the tall trees parrots nest in.

A study of African grey parrot populations in Ghana, part of the bird's wild range, shows that the species has been "virtually eliminated" there. Numbers have plummeted by 90 to 99 per cent since 1992 (*Ibis*, doi.org/9gm).

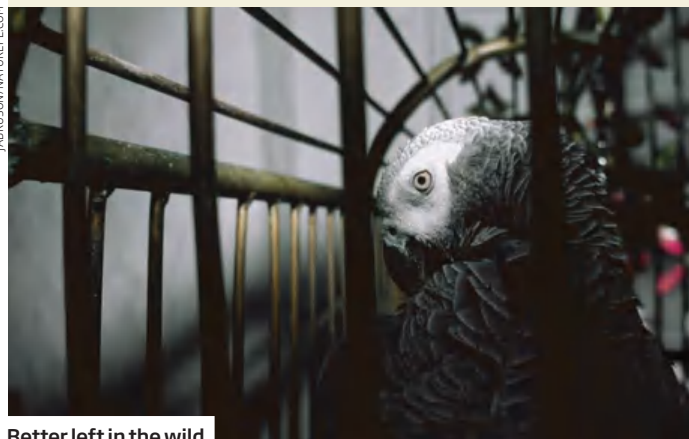
A team led by Nathaniel Annorbah of Manchester Metropolitan University, UK, found grey parrots in only 10 of 42 forested areas, each 100 square kilometres. In three roost areas that two decades ago harboured between 700 and 1200

birds apiece, they found only 18 parrots in total. The local people they interviewed mainly blamed felling of timber and the pet trade.

Although populations are thought to be holding up in countries further east, such as Cameroon, Annorbah's team says that if Ghana is anything to go by, the future for grey parrots is grim.

A recent report found that some 15,000 grey parrots are taken every year from the eastern part of the Democratic Republic of the Congo. The annual quota for the whole country is 5000.

"It's pretty shocking," says co-author Nigel Collar of BirdLife International. "It's very difficult to know what can be done."



Better left in the wild

60 SECONDS

Blowhole blockage

It's the David and Goliath story replayed as tragedy. Two pilot whales have been killed by sole fish 1000 times smaller. The fish were found stuck in the whales' blowholes, probably trying to escape while being eaten (*PLOS One*, doi.org/9gr).

One tiny leap

Time is out of joint. To keep the time according to Earth's rotation in sync with that of atomic clocks, a "leap second" must be added to the year. But some think the update would be too expensive, so representatives at the World Radiocommunications Conference in Geneva this month postponed a vote about whether to add the second until 2023.

Chimps retire

The last 50 research chimps belonging to the US National Institutes of Health are set to retire, following the NIH's announcement that it will no longer back medical research on chimpanzees. No new proposals using chimps have been approved since June 2013.

CubeSat boom

It's the age of the CubeSat. Rocket firm United Launch Alliance has announced that these small, cheap and easy-to-build satellites will be getting a boost from 2017. The company is developing a standard carrier for its Atlas V rocket that will be capable of deploying up to 24 CubeSats every launch.

Jolie effect

The number of women having preventative double mastectomies has more than doubled in a year, according to records at one clinic in Manchester, UK (*Breast Cancer Research*, DOI: 10.1186/s13058-015-0650-8). Researchers say the increase may be due to a raised awareness of cancer-associated *BRCA1* and *BRCA2* gene mutations, prompted by actor Angelina Jolie's decision to talk publicly about her own preventative surgery in 2013.

Climate talk hope versus reality

The UN climate treaty being negotiated in Paris is supposed to put us on track to prevent dangerous warming. Some say it's too late. Read both sides and make up your own mind, says **Michael Le Page**

DO CLIMATE TREATIES WORK?

OFFICIAL VIEW: THE PARIS PROTOCOL WILL BUILD ON THE SUCCESS OF KYOTO

International efforts to tackle climate change began at the Earth Summit in Rio de Janeiro in 1992, leading to the 1997 Kyoto Protocol. Earlier this year, the branch of the United Nations that oversees climate negotiations, the UNFCCC, declared the protocol had proved that climate agreements work.

The protocol required that, by 2013, industrialised countries cut their greenhouse gas emissions by an average of 5 per cent relative to 1990 levels. While some failed, most beat their targets. Their collective emissions fell by about 23 per cent. "The Kyoto Protocol was a remarkable achievement in many ways," Christiana Figueres, head of the UNFCCC, has said. "It clearly played an important role in catalysing this promising trend, which has led to a collective and very welcome 'over-achievement'."

The protocol also "put in place pioneering concepts, flexible options, practical solutions and procedures for accountability that we often take for granted today", Figueres said.

CRITICS' TAKE: PARIS DEAL WILL HAVE SAME WEAKNESSES AS FAILED KYOTO PROTOCOL

Developing countries were not required to make cuts under the Kyoto Protocol. A number of industrialised countries - including the US, then the biggest polluter - didn't sign up and Canada withdrew in 2011.

The fall in emissions in the 36 industrialised countries that stuck with it has been far outweighed by increased emissions in China and elsewhere. Global emissions have soared, and the level of carbon dioxide in the atmosphere - the factor that directly affects the climate - is increasing faster than ever.

What's more, not much of the fall in industrialised countries can be attributed to the protocol. Much of it was due to manufacturing shifting to China, and to the financial crisis of 2008. The final form of the Paris deal is yet to be decided, but it's clear it will suffer from many of the same problems as its predecessor.

"The Kyoto Protocol was a remarkable achievement - it pioneered concepts we take for granted today"



Emissions have shifted from developed to developing nations - and they are still rising

CHRIS SATTILBERGER/ANZENBERGER/PLAINPICTURE

CAN A NEW DEAL BE REACHED IN PARIS?

OFFICIAL VIEW: A DEAL LOOKS LIKELY - THE POLITICAL WILL IS THERE

The countries that signed up to the 1992 climate convention - the Conference of the Parties or COP in diplomatese - started meeting every year in 1995. The third COP meeting established the Kyoto Protocol, to run until 2012.

The infamous 2009 meeting in Copenhagen failed to extend the protocol beyond 2012. A major sticking point, as ever, was trying to get industrialised countries to sign up to bigger cuts when developing nations were allowed to increase their emissions.

Efforts in the last few years shifted from extending Kyoto to setting up a whole new climate treaty to run from 2020 to 2030. Instead of trying to impose targets on nations, individual countries have instead been asked to declare what they are prepared to do: their "Intended Nationally Determined Contributions".

Negotiators say the INDCs have exceeded expectations, and they are optimistic that a deal can be agreed at COP21 in Paris. Unlike with previous meetings, they say, there is real political momentum.

CRITICS' TAKE: WHETHER OR NOT A DEAL IS REACHED, IT WON'T BE ENOUGH

For many, just getting nearly 200 countries to sign a climate deal would make the Paris meeting a success. And they have a point. There are still issues that could scupper any deal, such as developing countries seeking compensation from developed nations for losses and damage related to climate change.

The ultimate aim, however, is supposed to be to limit global warming to 2°C - the questionable figure chosen as a "safe" limit. Figueres has said that any deal in Paris will not be enough to achieve this. But she insists that Paris will put us "on a pathway" to 2°C, or even better: 1.5°C. Yet to have a chance of staying below 2°C, total emissions after 2011 can't exceed 1000 gigatonnes of CO₂. The UNFCCC's own figures show that we will have burned through that budget by around 2036, even if countries stick to their INDCs.

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WILL COUNTRIES MAKE BIGGER CUTS AFTER PARIS?

OFFICIAL VIEW: PARIS IS JUST THE START. THE AIM IS TO RATCHET UP THE ACTION IN THE COMING YEARS

Any deal signed in Paris will establish a floor rather than a ceiling for cuts to greenhouse gas emissions by 2030, Figueres says.

The idea is that every five years or so, countries will be asked to review their targets to see if they can do more. The details have yet to be agreed, but it would have to be entirely voluntary to win support.

However, as the US has argued, clean energy technology is advancing, its cost is falling and political will to take action is increasing. For example, leaders of US and China have recently come together to back action on climate change. Many countries may be prepared to do more come 2020 or 2025.

The G8 countries and a few others have already said they will cut emissions by 80 per cent by 2050 – the minimum required to meet the 2°C target. More countries are likely to join them.



MONTY RAKUSEN/CULTURA/PLAINPICTURE

There is political will to act: some countries promise 80 per cent emissions cuts by 2050

CRITICS' TAKE: ANY RATCHETING UP WILL BE TOO LITTLE, TOO LATE TO STAY BELOW 2°C

Back in 1997, some hailed the Kyoto Protocol as a step towards the 2°C goal. Nearly two decades on, we have run out of time.

Even if every country took action in earnest today, extremely drastic – and politically unpalatable – measures would be required to stay below 2°C, as Kevin Anderson of the Tyndall Centre for Climate Change Research in the UK and others have shown.

The cuts on the table for Paris will not even stop global emissions growing. If we delay until 2020 or 2025, the time frame will be even more unrealistic.

As for the countries that have committed to an 80 per cent cut by 2050, none is on course to achieve it. The UK and Germany are going to miss 2020 targets for renewable energy. This does not bode well for tougher cuts in other sectors, such as agriculture.

“The cuts on the table for Paris will not even halt the rise in global greenhouse gas emissions”

CAN WE KEEP GLOBAL WARMING TO SAFE LEVELS?

OFFICIAL VIEW: THE PARIS AGREEMENT WILL AT LEAST KEEP WARMING BELOW 4°C

A series of recent analyses suggest that the proposals on the table for Paris would put us on course to keep warming below 3.7°C – perhaps as low as 2.7°C if rapid emissions cuts can be sustained well beyond 2030.

That may be warmer than 2°C, but it would still be a significant achievement – and far better than the alternative. Without efforts to cut emissions, we would be heading for a world well over 4°C warmer by 2100, with potentially catastrophic consequences on the climate and our lives.

If the Paris Protocol succeeds in increasing the ambition after it comes into effect, we may be able to get even closer to 2°C. And if we find ways to suck CO₂ out of the atmosphere on a vast scale – achieving so-called negative emissions – there is still a chance we can limit warming to 2°C or perhaps even lower.

CRITICS' TAKE: GLOBAL TEMPERATURES COULD RISE 4°C EVEN IF THE PARIS PROTOCOL IS WILDLY SUCCESSFUL

By failing to cut emissions, we are taking a huge gamble. Even if we somehow stick to the target budget of 1000 gigatonnes of CO₂, computer models suggest the resulting warming in 2100 could range from 1.3°C to 3.9°C – and keep climbing to 6°C by 2200 in the worst case. And the models could be underestimating the range of outcomes because they do not fully factor in all the sources of feedback that could cause warming.

So when you read about limiting warming to 2°C, remember this is far from guaranteed: it is just the most likely out of a range of possible outcomes. Worse still, it now seems certain that we will bust the carbon budget, and many scientists think plan B – sucking lots of CO₂ out of the atmosphere – will prove impossible. Maybe we'll get lucky, but some very scary scenarios cannot be ruled out.



DIETER HEINEMANN/GETTY

Sizzling treatment

How high-fat diet for epilepsy affects the brain

Clare Wilson

EGGS, steak, and butter on everything – it's not like most health food diets. But the high-fat "ketogenic" diet can be an effective last resort method of reducing seizures in people with epilepsy that doesn't respond to drugs, and may even help a range of other brain conditions. Now researchers may have figured out how it works – and how to make the method more palatable.

"All the time, you're looking at getting the fat in," says Emma Williams, whose son Matthew used to eat like this. Breakfast might be scrambled eggs with lashings of butter, followed by a lunch of steak and salad, covered in oily dressing. "If we ate out, I'd take butter and oil with me," says Williams.

According to early-stage research, the high-fat ketogenic

diet may also help several other brain conditions, including Alzheimer's disease and schizophrenia. The diet seems to have slowed or even stopped cancer growth in a few people with brain tumours who started to follow it to control seizures. When given to mice with tumours, it amplified the effects of radiotherapy. The results are so

intriguing that a small trial of the diet in people with brain tumours is planned for next year.

But by far the most common use is for epilepsy. The ketogenic diet has been used in children with severe epilepsy since the 1990s. Two-thirds of those who try it see their number of seizures fall by half or more. In some cases, as happened for Matthew,

children can later be weaned off the diet without their epilepsy becoming worse again.

Until now, the mechanism behind these effects had been a mystery. Now researchers have discovered that one of the breakdown products of fat binds to molecules on the surface of brain cells, calming the storm of electrical activity that can cause epileptic seizures.

Calm the storm

Our cells usually get their energy from glucose, which comes from the carbohydrates we eat. But when these aren't available, the liver breaks down fat into fatty acids and ketones, so that our cells can burn ketones for energy instead. In epilepsy, the thinking has long been that these ketones somehow make neurons in the brain less likely to fire, preventing seizures.

But there was still a puzzle: higher blood ketone levels in those following the diet don't necessarily correlate with fewer seizures. Instead, it has been suggested that a fatty acid called decanoic acid is responsible for the effect. Previous work found that directly feeding this compound to mice with a version of epilepsy reduced their seizures.

Now lab tests using frog cells have shown that decanoic acid directly binds to a molecule that is found on the surface of brain cells and is known to be involved in spreading electrical impulses

FROM EGG TO COCONUT

Decanoic acid, which seems to be responsible for the ketogenic diet's beneficial effects on epilepsy (see main story), is naturally present in some foods, including coconut oil.

Two trials of the compound's efficacy are due to start next year, one in children, the other in adults.

But the ketogenic diet is so extreme that some people have

already been following a modified form, on medical advice, with reduced fat but large amounts of coconut oil – even before the role of decanoic acid had been uncovered.

However, Robin Williams of Royal Holloway, University of London, advises against DIY experimentation for those currently prescribed the standard form of the diet. "Epilepsy is a very severe condition and people

should not self-medicate."

If the trials go well, decanoic acid may lead to easier regimes. But in the meantime, support for those sticking to the ketogenic diet is available from Emma Williams's charity Matthew's Friends. "The work is nothing in comparison to seeing your child having hundreds of seizures a week. Anything is better than that," she says.

between different neurons (*Brain*, DOI: 10.1093/brain/awv325). When decanoic acid binds to it, it reduces the flow of electrical current into the cell via this molecule. "It reduces the chance of a neuron firing," says Robin Williams of Royal Holloway, University of London.

His team's finding could lead to easier dietary regimes that get the same result. "It's a strong theory, and if it translates into practice we could use a more acceptable diet," says Helen Cross of Great Ormond Street Hospital for Children in London, who wasn't involved in the research. She plans to trial giving decanoic acid directly to people.

This could enable more people with epilepsy to benefit from the diet's effects. The ketogenic regime seems to work for adults too, but few follow it because it's so hard to stick to. In the standard version, people have to make sure around three-quarters of their

"Directly feeding decanoic acid to mice with a version of epilepsy reduced their seizures"

food is fat. "It can be daunting," says Emma Williams. "You have to weigh every gram of food."

But simply adding decanoic acid to food won't be enough. Under a typical high-carb diet, the body would still rely on glucose for energy, and store away the decanoic acid as fat. To make sure that the decanoic acid gets into the brain, people would still need a relatively low-carb diet – but not as low as the current ketogenic diet, says Robin Williams.

For instance, in Cross's trial, due to start next year, children with epilepsy will be given decanoic acid twice a day, in the form of a yogurt-like drink. They won't be able to eat sugary foods, but will be able to eat plenty of carbs like wholemeal bread and pasta, which release glucose into the blood more slowly. "It's a lot more acceptable," says Cross. "And there's no measuring involved." ■

Flying gold sent the moon tilting

WOULD you trade all the world's gold for a chance to see a solar eclipse every month? The same space rocks that brought precious metals to Earth's surface may also have knocked the moon's orbit off-kilter, robbing us of a regular light show.

We think that the moon formed when a Mars-sized object collided with the proto-Earth around 4.5 billion years ago, splattering material into a disc that eventually coalesced into the moon. There is just one problem: this disc would have been more or less aligned with the planet's equator, as Saturn's rings are. So why does the moon today orbit at a wonky 5 degrees?

Researchers have come up with a variety of theories to explain this tilt, but none is completely satisfactory, says Robin Canup at the Southwest Research Institute in Boulder, Colorado. "They involve relatively complex processes and rather constrained sets of uncertain parameters."

Now Kaveh Pahlevan and Alessandro Morbidelli at the University of Côte d'Azur in Nice, France, say they have a better idea. "We did a very simple experiment by considering that the moon-forming impact was not the last – there were others bodies around," says Pahlevan.

They carried out thousands of simulations of the Earth-moon pair just after it formed, when protoplanets still thronged the solar system. Over tens of millions of years, these protoplanets would repeatedly pass the pair. Occasionally, they would get close enough to gravitationally tug the moon away from the equatorial plane, before crashing into the Earth.

The results suggest that encounters with just a handful of

protoplanets, around the moon's mass or slightly smaller, would have been enough to tilt the moon at the angle we see today (*Nature*, DOI: 10.1038/nature16137). "It's a few of those very closest encounters that dominate the overall effect," says Pahlevan. "There is an element of chance here."

Rare eclipse

That roll of the dice means it is quite possible the moon could have stayed in its original position. If that had happened, its orbit would line up exactly with the sun and Earth twice every month, treating us to regular solar and lunar eclipses. The actual tilt makes those eclipses much rarer, as the moon only strays into the plane between

the Earth and sun twice a year.

We already suspected that these collisions had taken place, says Canup. Precious metals like gold and platinum should have sunk into the Earth's core as the planet formed, leaving almost nothing on the surface. Instead the metals are relatively abundant. They must have arrived here after Earth formed – carried by the exact same protoplanets that Pahlevan and Morbidelli now say skewed the moon's orbit.

"There are still uncertainties here, but overall I think this is a very compelling and quite testable hypothesis," says Canup.

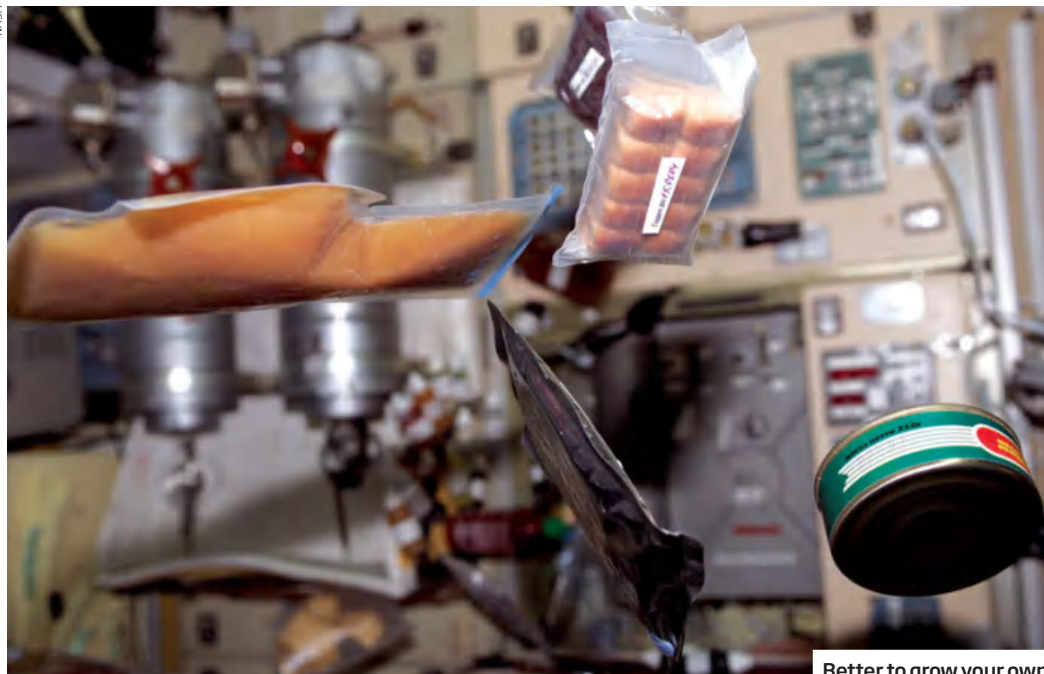
Those doomed space rocks had an impact both literally and figuratively. "If there had not been this late accretion, we would have had frequent eclipses but we would not have the precious metals," says Pahlevan. With both playing such an important role in the culture of early civilisations, we can only speculate how a few off-course rocks might have altered the course of history.

Jacob Aron ■



Eclipses: more often would be nice

GARY HERSHORN/REUTERS



Better to grow your own

Mission Astro-food: Sugar to be made in space by microbes

Clare Wilson

MATT DAMON'S character in *The Martian* has to grow potatoes in his own faeces to survive on Mars. But there may be more appealing ways to make food in space, like using bacteria to make chemicals we can eat, such as sugar.

"The first pilgrims who came to the Americas didn't bring all their food for the rest of their lives," says Lynn Rothschild of NASA's Ames Research Center. "You need to live off the land."

The idea is now set to be put to the test in space for the first time. Genetically modified bacteria will be sent up on a German satellite in 2017 to see if they can survive the launch and cosmic radiation, and function under reduced gravity.

The satellite will spin for six months at a speed that simulates Martian gravity, which is one-third that on Earth. It will also test the same bacteria under lunar and zero gravity, to see if they

could function on the moon or a space station.

The sugar could be turned into not only food, but also fuel. And bacteria could also be engineered to make drugs and building materials (see "Bacterial origami", below), slashing a spacecraft's

payload. "Launching things against Earth gravity is extremely expensive. This is the obvious way to break through the problem of 'upmass'," Rothschild says.

The linchpin is a type of plankton called *Anabaena*, which uses photosynthesis to make

BACTERIAL ORIGAMI

E. coli bacteria have been engineered to make sheets of folding plastic. Astronauts on long missions might one day rely on such bacterial origami to make tools on the go.

One way to save room on long space trips is to pack plastic sheets to be folded later. Manufacturing the material at your destination would be even better.

To this end, Lynn Rothschild of NASA and her team have genetically engineered strains of *E. coli* to create plastic, which in turn can use ink or spores to fold itself into 3D shapes when heated. They presented their

plastic creations at the International Genetically Engineered Machine competition in Boston in September.

The team were inspired by plastic tableware in the NASA cafeteria, which they placed under heat lamps to see what kind of plastic would work best. Next, they figured out how to genetically engineer strains of *E. coli* to produce each type of plastic in the lab.

They successfully folded simple structures including a box and a cup. In future, they envision more complicated items like solar sails or origami habitats. Aviva Rutkin

sugars from carbon dioxide, water and sunlight.

Rothschild's team has tweaked the microbe's genes so that it excretes some of the sugars to provide a food source for other modified bacteria, a system they have dubbed PowerCell.

The team has engineered a microbe called *Bacillus subtilis* to turn those sugars into a red

"The first pilgrims didn't bring all their food for the rest of their lives. You have to live off the land"

pigment. Some *B. subtilis* will fly with PowerCell, and any colour change will be detected by an on-board sensor. That will show whether the bacteria are behaving as intended, as the satellite will not return to Earth, but burn up in the atmosphere after a year.

A key question, says Rothschild, is whether the *Anabaena* spores will germinate when rehydrated on the satellite. She has more faith in the *B. subtilis* spores, which have been tested in space before.

The satellite will carry experiments for more conventional food as well. In another first, the German team controlling the satellite will grow tomato plants by using bacteria and algae to turn synthetic urine into fertiliser, says team leader Jens Hauslage at the German Aerospace Centre's Institute of Aerospace Medicine. Earlier this year the first lettuce grown from seed on the International Space Station was tasted by astronauts.

NASA says it plans to send people to Mars by the 2030s, although some say this date is optimistic. But whenever it takes place, the mission will need to be as self-sufficient as possible, says Amor Menezes of the University of California, Berkeley.

Still, Menezes points out that it is early days for space food. "Space engineers are very conservative," he says. "Biology is something that has really not been considered yet." ■

The 17th-century plot to use hats as bioweapons

Debora MacKenzie

DON'T try on that fez. During the world's longest siege, a 17th-century scientist hatched an ambitious plan – to weaponise the bubonic plague by painting it onto hats.

The plot, which has just come to light, was discovered by Eleni Thalassinou at the University of Athens in Greece and her colleagues in six letters sent between 1649 and 1651. During that time, the town now known as Heraklion in Crete was under Venetian control but besieged by Ottoman troops.

Michiel Angelo Salamon, a doctor in what is now Croatia, had an idea. The letters, sent between the rulers of the Venetian empire and the governor of a Croatian outpost, detail Salamon's scheme

"The governor proposed painting liquid expressed from carbuncles onto goods for the besiegers"

for harnessing the plague, the deadly infection that swept across Europe in 1348 and had been circulating there ever since.

Salamon appears to have devised a method for distilling the essence of plague. "He availed himself of the presence here of the plague to distil a liquid expressed from the spleen, the buboes and carbuncles of the plague stricken," wrote the governor of Zara (*Historical Review*, doi.org/9fs).

The governor proposed painting this liquid onto goods that besieging Turks were likely to buy – such as hats known as Albanian fezzes.

Such a plan reflects people's understanding of the plague at that time: that it spread from person to person, and could be transmitted through cloth

contaminated by bodily fluids.

The Venetian authorities were enthusiastic, but insisted Salamon personally oversee his plan – which he reportedly agreed to with "great unwillingness". However, we do not know whether he ever executed his scheme because the letters end in 1951.

But if he did, it didn't succeed. The Ottoman siege lasted another 18 years. Today, we know that the plan was unlikely to have worked. In 1884, historians proposed that the bubonic plague was caused by bacteria carried by rodent-borne fleas. Salamon kept his jar of plague potion for several years, by which time any bacteria it contained would have died.

Salamon's plot wasn't the first biological warfare plan based on a limited understanding of how diseases spread. Earlier medieval tactics included throwing rotting carcasses over the walls of besieged towns in the belief that bad smells could spread disease. Historical accounts suggest this did sometimes work, according to research by Mark Wheelis of the University of California at Davis, either by actually spreading germs, or just by making a place stink too much to remain there.

Later would-be biowarriors turned to smallpox. Documents from 1763 show that British commanders gave blankets and a handkerchief from smallpox victims to Delaware Indians, intending to spread the disease, although it is not clear if they succeeded.

But at least one siege does seem to have been broken by using bioweapons. In 1776, British troops managed to end the American siege of Quebec by inoculating prostitutes with smallpox and sending them out of the city. Unlike later vaccines, this early method also transmitted the disease. ■



CHRISTIE'S IMAGES/CORBIS

Send in the hats

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Close-up of living blood vessels

Helen Thomson

BREAK out the bubbly. We have the clearest images yet of blood vessels in live animals, thanks to microbubbles.

The new ultrasound technique allows doctors to image organs deep in the body in microscopic detail for the first time, and will aid the diagnosis and treatment of diseases such as cancer and strokes.

The resolution we can reach when imaging organs is limited, and compromises have to be made between clarity, speed and how deep inside the body we try to look.

But tiny gas-filled bubbles about 2 micrometres in diameter can give a clear view of deep tissues in close to real time. By injecting these microbubbles into the organs of a live rat and targeting them with ultrasound, Mickael Tanter at the Langevin Institute in Paris and his colleagues have visualised its tiniest blood vessels.

The technique takes advantage of how high-frequency ultrasound waves interact with

these microbubbles. When one hits a microbubble, some of its energy bounces back. Tanter says that if ultrasound imaging is used at a high-speed rate of several thousand frames per second, echoes can be

distinguished coming from each individual bubble in each frame, allowing his team to track their exact location as they travel throughout the blood system.

It took the team just tens of seconds to create an image of the blood vessels in the rat brain with pixels about the size of a red blood cell. In small animals such as rats, ultrasound waves can normally only be used to image features of about 150 micrometres or more. By using microbubbles, Tanter

and his team managed to create images with a resolution of 10 micrometres (*Nature*, DOI: 10.1038/nature16066). He says they already know they can do better, and that they will soon reach a resolution of only 3 micrometres, even when imaging deep-seated organs such as the liver.

This kind of microscopic imaging will soon be used in clinics to help us understand diseases that modify blood-vessel systems, says Tanter. For instance, the number of tiny vessels that appear alongside tumours when they start to form can help doctors diagnose what stage a cancer is at. "It will also be used to map the whole brain at unprecedented resolutions and give new insights in the understanding and follow-up of stroke," says Tanter.

This is a very exciting new technique, says Eleanor Stride, who studies the therapeutic use of microbubbles at the University of Oxford. She says that the possibility of replacing current imaging techniques for visualising the blood supply, which use potentially harmful radiation, is great news for patients. "Being able to image micro-scale blood vessels is extremely important for accurate diagnosis and treatment monitoring in multiple diseases," she says. ■



Rat brain: microbubbles reveal all

ESPC/INSERM/CNRS

Protein turns cells into insulin forges

WHAT an incredible transformation. A protein that persuades normal pancreatic cells to make insulin could help people with type 1 diabetes avoid daily injections.

Insulin keeps the amount of glucose in our blood at a safe level. But in type 1 diabetes, the immune system destroys the beta cells in the pancreas that make insulin. Injections of the hormone are then needed to keep blood glucose levels down.

Now, a team led by Juan Domínguez-Bendala at the Diabetes Research Institute in Miami, Florida, has transformed non-beta cells in the pancreas into insulin-producing cells.

Domínguez-Bendala and his colleagues added a protein called BMP7, which helps bones to mend, to a soup of pancreatic cells that don't normally produce insulin. This made them produce high amounts of the hormone. And the cells secreted even more when exposed to glucose – just as beta cells do in healthy individuals. "We are very encouraged by the simplicity of our finding," says Domínguez-Bendala.

When the team put treated cells

into diabetic mice whose own beta cells had been destroyed, the cells acted like healthy beta cells.

The team hopes to inject BMP7 directly into pancreases to allow people with type 1 diabetes to make their own insulin. For this to work, immunosuppressive drugs would also be needed to protect the cells from the misbehaving immune system.

Another possibility would be to create new beta cells from donor cells and implant these. Transplants of

donated beta cells are done, but only some 2 per cent of cells in a pancreas are beta cells – enough for just one recipient.

The team hopes to use BMP7 to convert the other 98 per cent of donor pancreas cells into beta cells, which, they estimate, could provide enough insulin-producing cells from a single pancreas for seven people.

Alasdair Rankin, at charity Diabetes UK, says that improving the number of cells for transplant is a major focus. "This study describes a promising approach, but it will be some years before we know whether it will be effective in medical practice," he says. Andy Coghlan ■

"One pancreas could provide enough insulin-producing cells for seven people with diabetes"



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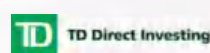
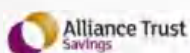
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Mollusc sees with hundreds of eyes made of pure rock

EYE see you. The West Indian fuzzy chiton, a small marine mollusc, lives a sheltered life protected by its tough armoured shell. Like a knight peering over the battlements of a castle, it can see the world without venturing out of its fortress – using hundreds of tiny rock-hard eyes embedded in its shell. Each eye lens is, uniquely, made of aragonite minerals, not proteins.

In 2011, researchers discovered that these eyes work just like ours. The mineral lenses focus light on the animal's retina, which is covered in photoreceptors. "The difference is they're embedded in rock and the lens itself

is made out of rock," says Sönke Johnsen, an ecologist at Duke University, North Carolina.

Now, for the first time, scientists have seen what the world looks like to a chiton. Ling Li of Harvard University and his colleagues popped the lenses out of the shell and put them in a microscope to act as an additional lens, then attempted to focus the image of a predator fish.

They found that mineral lenses have pretty good resolution. But each eye is so tiny that there are only about 100 cells in the retina. Each retinal cell acts like a pixel on a computer screen, so the mollusc would see an extremely pixelated image with each of its eyes – pretty much just a blob (*Science*, doi.org/9df). But an indistinct blob is enough of a warning for chitons – all they need to do is clamp down onto the rock and hold on for dear life.

Weird flashes run on black hole batteries

IT'S the ultimate alternative energy source. Some of the mysterious radio signals from beyond our galaxy may be powered by cosmic batteries. Black holes and neutron stars could hook up into a kind of circuit just before they collide, producing ultra-short, ultra-bright blasts of radio waves.

Since 2007, just 11 fast radio bursts have been detected. These flashes release more energy in a

few milliseconds than the sun does in a month. Their origins have baffled astronomers.

Now a study by Janna Levin of Columbia University in New York and her colleagues suggests that some come from black holes and neutron stars – the dense cores of collapsed stars – spiralling towards each other.

According to Levin, when the black hole passes within the

neutron star's magnetic field, the motion from the objects' orbits and spins generates an electric current. Charged plasma particles flow along the magnetic field lines that stretch between the two bodies, and some of their energy gets converted into radio waves.

In the last milliseconds before these two dense objects merge, the radio waves become super-bright. From far away this looks like a flash (arxiv.org/abs/1511.02870).

Thieving Milky Way stole a star cluster

IT'S the case of the purloined star cluster. The Crater cluster, discovered far out in the Milky Way in 2013, is so odd it must have been stolen from a neighbour.

Most clusters in our galaxy huddle near its centre, but this one is 17 times further from the centre than Earth is. Daniel Weisz at the University of Washington in Seattle and colleagues found that it is also just 7.5 billion years old – much younger than other clusters of its type in the Milky Way (arxiv.org/abs/1510.08533). That suggests it's not from around here.

Weisz suspects the cluster was stolen from the Small Magellanic Cloud, a bright galaxy that orbits the Milky Way. Its location, speed and chemical composition are consistent with that origin.

But it could also have come from a much smaller galaxy that the Milky Way's gravity ripped apart – making our galaxy not just a thief, but a cannibal as well.

Whales seem to like mountaineering

SOME whales love mountains. New Caledonian humpbacks migrating between their breeding and feeding grounds pull over for days on end in waters around underwater mountains – though no one yet knows why.

It could be that they use them as navigation cues, or spots for feeding or breeding activities, such as singing by males, say Claire Garrigue and her team at Opération Cétacés in Nouméa, New Caledonia. They tracked 34 whales migrating between New Caledonia and Antarctica using satellite tags (*Royal Society Open Science*, DOI: 10.1098/rsos.150489).

"Maybe they stop there to relax and to rest a little bit because they have lots of miles to go to Antarctica," she says.

Tap dancing bird is one-man band

IT'S like real-life *Happy Feet*. An African finch has a penchant for tap dancing so fast that we can only see it with the help of a high-speed camera.

Blue-capped cordon-bleus (*Uraeginthus cyanocephalus*) tap dance with their partners, as part of a complex song and dance duet. "High-speed tap dancing is not reported in any other species," says Masayo Soma from Hokkaido University in Japan.

Soma first noticed a strange sound while the birds were dancing. So his team filmed them with a high-speed camera. The birds hold a piece of nesting material – such as a twig – in their beaks and bob their heads up and down while singing. As they bob up, they tap their feet between 25 and 50 times a second, creating a buzzing sound (*Scientific Reports*, doi.org/9dg). "It's a big mystery why cordon-bleus need such a way of communication," says Soma.

"It's not necessarily about mate choice," says Simon Griffith from Macquarie University in Sydney, Australia. Once these monogamous birds pair up, there is no need for courtship rituals. But they do need to coordinate the partnership. "They have to make decisions about when they're going to mate, when they're going to move around and how many eggs they're going to lay."



NAO OTA

Vocal cords grown from scratch to restore lost voices

SAY what? Researchers have grown the world's first vocal cords from scratch. The breakthrough could one day restore speech to people who have lost their voices through surgery or disease.

The vocal cords were built by seeding collagen scaffolds with cells from five human donors. The cells were coaxed into forming tissue that mimics vocal fold mucosa – the flaps in the larynx that vibrate to create the human voice. It took just two weeks to create each of 170 flaps.

Researchers tested the vocal

cords by attaching them to larynxes extracted from dogs.

"We put the larynxes with the folds attached onto a fake windpipe and blew warm air through them," says Nathan Welham at the University of Wisconsin School of Public Health in Madison. The result resembled a robotic kazoo, he says. "It was an eeee-like sound."

The sound matches that made by natural human vocal folds in isolation. The rest of the human voice is created by modulation of the mouth and throat.

When the team tested the folds in mice with human immune systems, the tissues were not rejected as foreign but were "immune-privileged". This suggests that human recipients wouldn't require any immunosuppressant drugs (*Science Translational Medicine*, doi.org/9dh).

"Loss of voice has a devastating impact on a patient's quality of life, so engineering a living replacement is a very important milestone," says Harald Ott of Massachusetts General Hospital.

Monkeys use stick shovel to steal eggs

CAN you dig it? Capuchin monkeys have been spotted using an improvised shovel to steal eggs from caiman nests in the Amazon rainforests in Brazil.

The monkeys grab a long stout stick and dig away at a caiman's nest mound, flicking the rotting vegetation aside until they reach the eggs – which they then eat one at a time.

It's a risky strategy. The metre-high mounds are often guarded by mother caimans, who leave them only occasionally to feed. "The nests are large, the eggs are buried deep, and those mothers are really aggressive," says Rafael Rabelo of the Mamirauá Institute in central Amazonia. He presented the discovery with his colleague Kelly Torralvo at the 16th Congress of the Brazilian Primatological Society from 9 to 13 November in Manaus.

Although individual caiman nests may be raided, the overall population is unlikely to suffer. The area has one of the highest caiman densities in South America. "The monkeys might get some, but that's not even going to dent the population," says Torralvo.



MICHAEL GURVEN

Women's fertility boosted by worms

CAN a parasite ever be good for you? Although some lower female fertility, there's evidence that those infected with roundworm have more children.

This seems to be the case for the Tsimane people of the Bolivian Amazon. The average woman gives birth to nine children, and parasitic worms are very common, infecting 70 per cent of the population.

To see how these parasitic worms might affect fertility, Aaron Blackwell of the University of California, Santa Barbara, and his colleagues collected data from 984 women over nine years. They found that women who

had a type of hookworm tended to have three fewer children on average, but those infected with roundworm had two more (*Science*, doi.org/9dk).

The size of the effect is surprising, says Blackwell. "We hadn't predicted such large changes in fertility."

Differing immune responses may be responsible. Hookworms provoke a type of immune cell that may harm developing embryos, whereas roundworms seem to encourage the immune system to change in a way that is similar to a shift that occurs during pregnancy.

AN OPEN LETTER



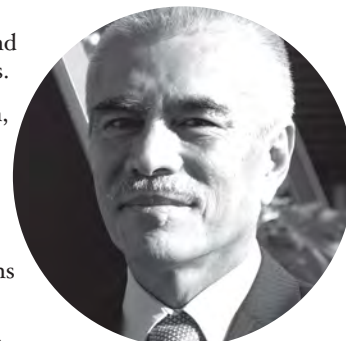
Dear World Leaders,

We, the undersigned, urge you to support a global moratorium on the construction of new coal mines and coal mine expansions — a moratorium called for by the President of Kiribati, and Pacific Island nations.

The scientific evidence is clear: to prevent severe and potentially catastrophic damage to human health, economic development and global stability, the world must as soon as possible start using less coal. Consistent with the rapidly shrinking carbon budget, the vast majority of coal reserves are unburnable and must stay in the ground. In short, there is no space for new coal.

Yet while the world negotiates a deal to reduce emissions, countries with large coal reserves are planning large expansions of coal production. These plans, if successful, would lock-in new coal emissions and are incompatible with tackling the threat of climate change.

A moratorium on new coal mines would be an immediate and concrete step towards decarbonizing the world economy. A world that is tackling climate change needs fewer mines, not more.



HIS EXCELLENCY ANOTE TONG
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PORSCHE

Flower power

A rose circuit could be the first step towards a new field of botanical computing, finds **Aviva Rutkin**

IT'S all coming up roses. The worlds of botany and consumer electronics don't typically overlap. But now a device has taken a step towards a world in which plants and computers are intertwined.

Magnus Berggren at Linköping University in Sweden and his team have built a working electronic circuit from a garden rose by filling its veins with a conductive polymer.

The experiment opens the door to electronics that can plug in to plants. Living tissues are known to be conductive – with slime moulds already finding their way into gadgets. Plants are no exception, and propositions include fuel cells powered by photosynthesis and crops that keep tabs on their own physiological properties.

But first, the Linköping team had to figure out whether it was even possible to weave electronics into the flesh of a plant – and the group struggled to find a suitable conductive material. It had to be water-soluble, with decent

electronics. The team soaked a garden rose, with its roots and leaves removed, in a solution of PEDOT. Over a couple of days, the plant's xylem network took up the polymer, which solidified as a gel. When the team peeled away the outer layers at the bottom of the stem, the researchers could see slender dark wires winding through the rose (*Science Advances*, doi.org/9fr).

The microscopy pictures taken by Eleni Stavrinidou, a postdoctoral researcher on the team, hinted immediately that the wires could work as circuits. "The performance, the shape of

the wires, were just outstanding, unbelievable," says Berggren.

The team managed to use these xylem wires to turn the plant into a transistor – a basic building block of computing and electronics. They tacked gold electrodes and probes along the length of the plant, connected it to an external resistor and ran a current through it.

The Linköping group isn't the first to try plugging into plant life. In 2012, a team at Disney Research led by Ivan Poupyrev linked orchids with a sensing technology that could measure how electricity moved through

the plant. Their project, dubbed *Botanicus Interacticus*, allowed the team to track and visualise the movements of a human hand along the plant's body.

And at the Massachusetts Institute of Technology, chemical engineer Michael Strano has created "Iron Man" plants with photosynthesis-boosting nanomachines embedded in their chloroplasts.

Berggren and his colleagues are interested in building botanical circuits that can sense and record changing hormone levels in plants. They imagine systems that might be able to nudge a plant's physiological properties in the desired direction, serving as an alternative to genetic modification. They also think that the biological circuitry could be useful for the paper industry, allowing them to exert more control over growing trees.

One stumbling block is that the technique doesn't keep the plant alive, because the rose's stem is severed before it is flushed with polymer, says Strano.

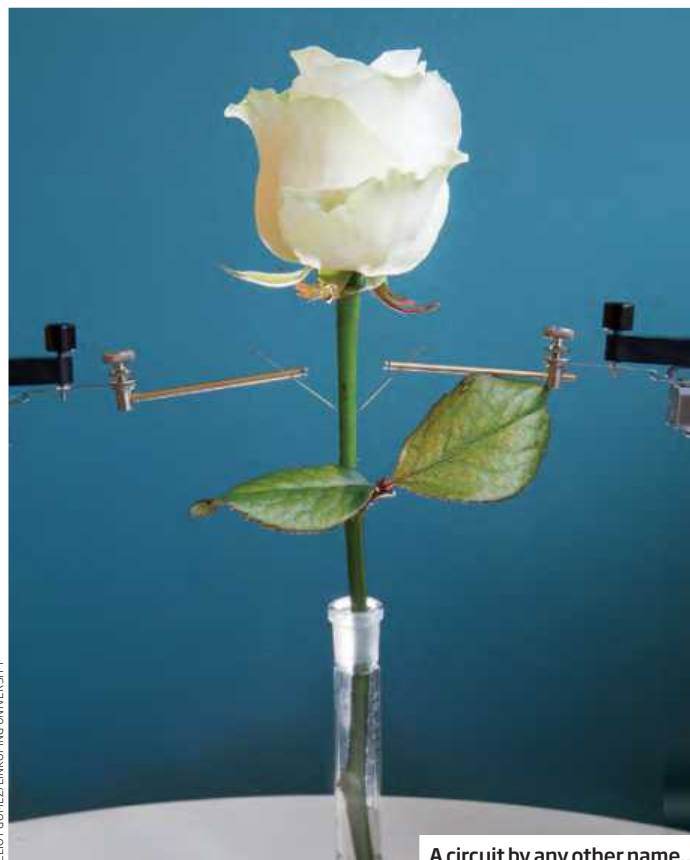
Others are more enthusiastic. The electronic rose is "yet another wonderful development in the field of living technologies", says Andrew Adamatzky, who directs the Unconventional Computing Laboratory at the University at the West of England in Bristol, UK, and has experimented with applying voltage to lettuce seedlings.

Adamatzky says this work opens the door to a weird new world: "In the very distant future – neither ourselves nor our kids will see this – we can grow vegetable computers in our gardens." ■

"The performance and the shape of the wires inside the rose's skin were just unbelievable"

electrical conductivity and be able to travel through a plant's vascular system and form wires. Many materials that the researchers tried were toxic to the rose, clogging up at the opening of the stem or failing to stick to the inner surface of the plant's veins – the xylem.

Finally, they found one that worked. PEDOT, or poly(3,4-ethylenedioxythiophene), is a conducting polymer used in



A circuit by any other name...

ELLIOT GOMEZ/LINKÖPING UNIVERSITY



GLAXIA/GETTY

Privacy apps will help you track the trackers

I KNOW I'm being watched as I browse for new clothes online. I decide not to buy anything, but a dress that I lingered on starts to follow me around the internet, popping up in ads on totally unrelated sites.

Adverts that pursue us around the web are a familiar experience, but they're just the most obvious manifestation of an intricate tracking network that follows our every move online. Now, researchers are building tools to help us understand not just who is tracking us, but how they are doing it, what they know, and how we can take back control.

Giving users control over their data can be tricky, since companies have built profitable businesses around "black box" algorithms that gather, crunch and share that data. At the Data Transparency Lab Conference at MIT in Cambridge, Massachusetts, last week, researchers gathered to discuss new ways to poke holes in those boxes and show people what's inside.

It's an uphill battle. Surveys show that ordinary users have no idea about what happens to our data online. A team led by Blase

Ur at Carnegie Mellon University in Pittsburgh, Pennsylvania, is helping to fill that knowledge gap.

They're developing a browser extension that keeps an eye on every third party that tries to grab your data. Every time you go to a site, the extension takes a note of which advertisers are there, looking at what you're looking at. It builds up a picture of what it thinks those companies have deduced about you: perhaps that you're a fan of ice hockey, or where you go at weekends.

"Every time you go to a site, the extension takes a note of which third-party advertisers are there"

Ur is planning tests to see if the extension improves user awareness or changes their behaviour. "We just want to provide transparency and see what impact that has," he says.

Web browsing isn't the only way we're tracked – social networks and smartphones are increasingly important. A system called the Facebook Data Valuation Tool, built by a team at Carlos III University of Madrid in Spain,

tries to calculate the monetary value in real time of the data users generate while they're browsing.

A project named ReCon, led by David Choffnes at Northeastern University in Boston, tracks how our smartphone apps connect to the internet, watching to see what information they are gathering. An experiment examining the top 100 most popular iOS, Android, and Windows apps detected information such as user location and contacts sent out in plain text, often from apps that had no need for that data.

"Users aren't aware of just how much they're being tracked," says Choffnes. In early run-throughs with ReCon, even he was surprised to see certain apps broadcasting personal characteristics about him that they'd inferred, like his gender, location and date of birth.

"Advertisers are clearly inferring and learning a lot about us as individuals; properties that may or may not make users feel uncomfortable. I at least want users to be able to look at that data and make their own decision about if it seems reasonable or not," Choffnes says.

His group is now working on a feature that will automatically notify users when it detects suspicious activity, giving them a chance to halt the traffic in its tracks if they want to. **Aviva Rutkin** ■

How to answer your phone with a flick of your foot

EVER tried to answer a smartphone with your hands full? Try your foot instead. KickSoul is an insole that you can slip inside shoes to control digital devices with a flick of your foot.

Xavier Benavides and his team at the MIT Media Lab sewed a gyroscope and accelerometer between two layers of spongy insole. The system's algorithm analyses the foot's motion and transmits the information via Bluetooth to your phone.

It recognises two foot movements: pushing an imaginary object away with your foot, and pulling one closer to you. With just two foot motions, you can scroll, zoom in and out on a map, accept or reject a phone call, save a file or delete it. The idea is that the smartphone's Bluetooth detects which compatible smart devices are nearby and works out which ones the user wants to operate. The algorithm can differentiate between fidgeting or walking and intentional movements.

Ten people tested the insoles and said they were comfortable and unobtrusive. The idea was presented at a user interface conference in North Carolina earlier this month. Benavides thinks the system is perfect for answering calls or turning on lights when laden with groceries, for example. "It's very useful because our feet are almost always free," he says.

Anna Nowogrodzki ■



PETRA HERBER/PLAINPICTURE

My phone has sole

Take a robot language class

Children can prepare better for school with a little robot help

LIFE is hard for immigrant children – new place, new friends, new language. Starting from next January, 4 and 5-year-olds in four cities across Europe will be getting a helping hand, by testing out robot tutors to help them get up to speed in the local language.

The project, called L2TOR, is run by linguists and roboticists from a consortium of universities across Europe. It aims to help young children gain the language skills they need when they enter the school system. The pilot will see children working with robots to boost their Dutch in the cities of Tilburg and Utrecht and German in Bielefeld, while kids in Istanbul in Turkey will get help with English.

L2TOR will have children work through a language course on a

tablet computer under the watchful eye of a NAO robot. These bots are made by French firm Aldebaran Robotics and are often used in classrooms (below). Before starting the lesson, the robot will explain what the child is going to learn, then, once the

“Robots have some advantages that humans do not – like infinite patience”

lesson is under way, it will observe the child’s body language and assist them when they get stuck.

“We want to help these children improve their language skills through one-to-one interaction with a robot, to help them catch up,” says Paul Vogt of Tilburg University in the Netherlands,

who works on L2TOR.

This is not the only project looking to use robots to boost learning. It’s well known that children learn better in one-to-one rather than class settings, but the cost and logistics of doing this with human teachers would be prohibitive. At Yale University, Aditi Ramachandran and Brian Scassellati are studying how 10 and 11-year-old children interact with robots. Their aim is to develop software that enables robots to understand students’ mental state and how much progress they are making in solving maths problems.

And at the Swiss Federal Institute of Technology in Lausanne, a system called CoWriter helps 6 to 8-year-olds practise their handwriting with robotic help. A NAO robot attempts to write a word on a tablet screen, and the child can step in and “teach” the robot where it went wrong, improving their own writing in the process.

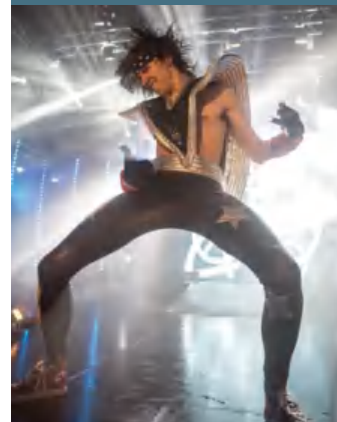
While human teachers are still the best when it comes to learning, robots are better than just using screen-based software, as in popular online courses. Learning with robots gives the child a tangible three-dimensional presence, which can help them learn more effectively.

Robots even have some advantages that humans do not – like infinite patience. “Sometimes the human teacher can get bored or angry by repeating things again and again,” says Amit Kumar Pandey, head of research and development at Aldebaran Robotics. “These kinds of psychological things will not affect the robot, they can repeat themselves as many times as necessary.” Hal Hodson ■



Good morning, Mrs Robot

ONE PER CENT



Air way to heaven

All those air-guitar dreams are about to come true. Kurv, a “stringless” guitar, promises to let anyone play music if they don’t mind looking a bit silly doing so. The instrument, which launched on Kickstarter, consists of an eight-button touchpad held in one hand and a digital pick in the other. The pick detects strumming motions and connects to your phone to play music.

90

Number of minutes for which the entire internet was down in Bangladesh earlier this month, after a botched government attempt to block communications apps to quell protests.

Unfriending love

Facebook is making it easier to get over your ex. The social network has launched a suite of tools designed to insulate you from your ex’s Facebook profile without unfriending them. Jilted lovers can switch off all mentions of an ex after they change their relationship status. They can also untag themselves from all posts they’re in together, and prevent the ex from seeing their profile. The tools have started rolling out to US users.

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Tough nut to crack

CRACKING this nut will take strength, skill and a grasp of physics – and the capuchin is equal to the task.

The monkeys choose nuts that are easiest to crack. An individual finds a groove in a log where one fits snugly, placing the flattest surface of the nut face down so that it's stable. Then it chooses a heavy stone, raises it above its head and hammers the nut with force.

The behaviour is considered one of the most complex forms of tool use by non-human species, putting the capuchin on a par with chimpanzees.

This alpha male, weighing 4.2 kilograms, is using a 3.5 kilogram stone to break into a piassava nut in Fazenda Boa Vista, Brazil.

He was photographed by Luca Antonio Marino, a biology student at Roma Tre University in Rome, Italy, who studied the foraging strategies of wild capuchins for his master's thesis. The image was a runner-up in the behaviour category in the Royal Society Publishing photography competition.

Sam Wong

Photographer

Luca Antonio Marino
lucamarino.weebly.com

Tilting at windmills

Is there a risk of chemical or biological terrorist attack by ISIS, as some have warned? It seems highly unlikely, says **Debora MacKenzie**

AS FRANCE and the world reeled from the terror attacks in Paris, French prime minister Manuel Valls warned last week that “there is also a risk of chemical and bacteriological weapons”.

Is there? Experts in such weapons are dubious. None of those I contacted believes ISIS can make chemical or biological weapons. The group, which said it carried out the Paris attacks, is likely to have used mustard gas in Syria, but it is thought to have just a few old shells salvaged in Iraq.

“I wondered if the French had new intelligence – until I heard Valls say, not chemical weapons, not biological weapons, but both together,” says Richard Guthrie, a chemical weapons specialist formerly with the Stockholm International Peace Research Institute in Sweden. Invoking this kind of generic threat is typical, he says, “after any terror attack



that causes extreme shock”.

After gunmen targeted Lod Airport in Israel in 1972, UK peer Lord Chalfont warned that “nowadays international terrorists will stop virtually at nothing. The chemical weapon is easily portable, cheaply made and easily used.” After two US embassies were bombed in 1998, President Bill Clinton talked of the “prospects... of chemical, biological and other kinds of attacks.”

Similar concerns were raised, including by me, after attacks on New York’s World Trade Center in 1993 and 2001. Yet there has been just one chemical attack (Japan in 1996), and a small biological one (the US in 2001). Neither were by foreign terrorists nor were they anywhere near the Paris toll.

These warnings seem to stem from a fear that, as Valls put it, the “macabre imagination of those who give the orders is limitless...

Worth a shot

A hunt for new alternatives to deadly force for the police makes sense, says **David Hambling**

INTEREST in safer substitutes for traditional firearms has surged in the US alongside the protest and debate over recent police shootings.

Many of the new alternatives are variations on the rubber bullet, blunt and heavy projectiles designed to incapacitate without breaking the skin.

The engineering challenge to

be both effective and safe is producing some novel designs. They include a plastic cap filled with silicone gel. The cap shatters on impact and the gel flattens to spread the blow over a large area. Safer Shot’s Bouncer projectile uses a putty-like substance to similar effect. SmartRounds Technology sells a non-impact

“flash bang” that explodes in front of the target and knocks them down with the blast alone.

These are typically known as “non-lethal weapons”, originally a military term, or “less-lethal weapons” as the police call them. But earlier non-lethal innovations proved capable of serious injury and death; by 1985 there was one death per 4000 plastic bullets fired in Northern Ireland. Dozens of deaths result from police tasers.

Anything that looks like a gun

“A new generation of substitutes for police guns, deployed with restraint, is at least worth exploring”

also attracts scepticism. The SALT gun, described as “a safe gun”, uses gas to fire projectiles that burst on impact, scattering the active ingredient from pepper spray. But it was dropped from a crowdfunding site following a Twitter campaign by anti-gun proponent Mike Monteiro, who argued that no gun can be safe.

It is hard to imagine a totally safe weapon. Even if something like *Star Trek*’s mythical phaser could safely stun someone, they might still crack their head.

There are other problems too. Neil Davison, adviser on weapons at the International Committee of the Red Cross, objects to the

we cannot exclude anything”.

Actually, we can exclude some things, up to a point. Of course no one can ever say for sure what the next attack will be. But germs and chemicals are hard to get and hard to use. The terrorists who struck Paris wreaked havoc with guns and bombs. Why do more? And why do we always fear they will?

Humans have an aversion to disease and poison that is profound, unreasoning and universal. In responding to an outrage, it seems prudent to fear the worst; chemical and biological weapons evoke the worst. It also seems responsible to warn people that the worst may happen.

But these warnings are futile: there is little civil defence against such weapons beyond hospitals or things like gas masks and vaccines – and most people won’t get their hands on those.

Officials who raise this spectre understandably want to look like they are doing something – or may be trying to win support for tough security measures. But vulnerable people are traumatised enough by current events. Raising not-terribly-founded fears just because they echo our worst nightmare isn’t going to help. ■

Debora MacKenzie is a consultant for *New Scientist*

language used. He wants the term “alternative weapons to firearms” to replace “non-lethal” to ensure they are not used against unarmed assailants.

The debate goes on. It may be tempting to reject alternatives because they are not “non-lethal”. However, in the US at least, this would leave police with little more than guns for subduing suspects.

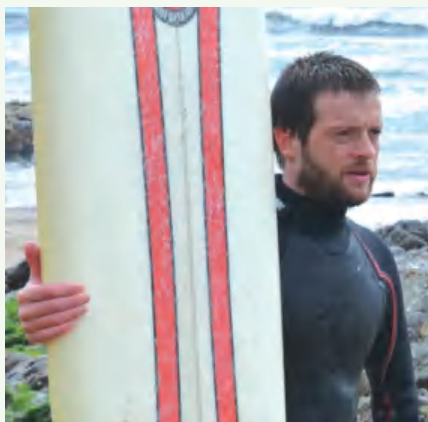
While the alternatives can be dangerous, firearms are deadly. A new generation of substitutes, deployed with restraint, is at least worth exploring. ■

David Hambling is a freelance science and technology writer based in London

ONE MINUTE INTERVIEW

Surfers on a mission

It is tricky to get coastal data, so **Bob Brewin** wants to recruit a volunteer surfer armada to help



PROFILE

Bob Brewin is a satellite oceanographer at Plymouth Marine Laboratory, UK. His research involves tracking sea surface temperatures from space. He is also a keen surfer.

You want surfers to help you monitor sea temperatures. Why would this be useful?

The coastal zone is extremely valuable to humans. It is where we interact most with the ocean, and it has the highest marine biodiversity. The problem is that it is difficult to sample using boats or buoys, because of waves. Surfers are always in and out of the water, so there’s a possibility that we could use them to acquire information on temperature. Temperature is particularly important because it controls the growth of marine organisms and, together with salinity, drives coastal currents that carry pollutants and contaminants.

What gave you the idea of people taking instruments out when surfing?

I had gone surfing with colleagues and we ended up driving up and down the coast to find a spot where there weren’t any people in the water. It dawned on me that with hundreds of surfers in the water there was a lot of potential to use them to acquire environmental data.

Why use surfers? Why not attach sensors to boats?

The techniques are easily transferable to other recreational watercraft. The focus on surfers is really to get observations of the near-shore environment. It is difficult to get a small dinghy into 3-4 foot (0.9-1.2 metres) of surf.

What monitoring equipment do you use?

We have been attaching a small temperature logger at the midpoint of a surfboard’s leash and putting a GPS device in a small waterproof waist bag for the surfer to wear.

You went surfing 85 times wearing this kit last year. What did you find?

We compared the temperature data collected by the kit with a very accurate buoy about 10 nautical miles offshore and with satellite data. The satellite observations agreed with the buoy data, but weren’t as accurate at the beach, where we collected data by surfboard. It is well known that satellite observations of sea temperature are not so reliable closer to the coastline. If a satellite isn’t capturing near-shore temperatures well, then temperatures collected by surfers may even help to improve the satellite data.

How many surfers are helping you so far?

We have a growing list, which currently stands at 40. We have also started discussions with the environmental charity Surfers Against Sewage to encourage more surfers to use the device.

How are you encouraging surfers to wear these monitoring devices and then send you the data afterwards?

By putting a GPS device on a surfer they can get interesting information, such as how many waves they have caught and how far they have gone on each wave, much like smartphone apps that monitor people’s performance when running. Surfers are also protective of their environment. The hope is that they will be interested in using these devices to monitor their beach.

Interview by Andy Extance

It's not a rocket it's an Up Goer

Is it possible to explain things like nuclear power stations and microwaves without using complicated words? **Randall Munroe**, creator of the cult *XKCD* comics wanted to find out...

How did you get the idea of explaining complex things using only the 1000 most common words?

The idea actually grew out of an *XKCD* comic I did. I was playing a computer game in which you have to design rockets and successfully launch them. My spaceships would always blow up, so every launch I needed to find a new name. I quickly got tired of giving them cool, majestic names like *The Falcon* and I started giving them stupid names like *Flying Space Boat*. The dumbest thing I could come up with was *Up Goer*. Then I started thinking, "Hey, what if I did a whole diagram where I labelled everything using really dumb words?"

How did you decide on the 1000 words to use?

I ended up going down a bit of a rabbit hole because there are so many different ways to define the most common words. You get wildly different answers if you draw on fiction versus non-fiction or speech versus text or email versus books. And you must have rules about how you combine words. So, "run" and "ran" probably count as the same word. But what about "runner"?

What methods did you use to create your list?

I looked at a few different lists and some of the words really didn't fit with my idea of a simple word. If you do a list based on newspapers, there are lots of words for institutions and words like "vote" and "education" that are not that common in other parts of our lives. So I spent several months going back over a bunch of different lists and generating some of my own based on the Google Books corpus and even my own email inbox. Then I combined the lists and where they disagreed I just let my sense of consistency be the tie-breaker. I really spent more time than I think I needed trying to find the best list of simple words.

How straightforward was it once the word list was fixed?

I could have made it easier for myself. There are a few words I was disappointed didn't make the cut. The biggest omission was a synonym for "rope" or "string". I didn't have "pipe", "tube", "thread" or "cable" on my list so when I was describing things like the ship *USS Constitution* – which has a lot of rope – the only word I had was "line". This fits in some contexts, but has so many other meanings that it was hard to work with. I was like, "Come on, people, we need to use the word 'rope' more often and this will be a lot easier."

With their limited set of words, the definitions in your new book *Thing Explainer* get to the real essence of things – like calling a lock a shape checker. Was that intentional?

Partly. My editors asked why I couldn't just call a lock a bad person stopper. But that isn't what they do. They're unusual pieces of technology because they offload decision-making to something mechanical. We think about locks as almost magical: only the right people can open them. But that's not correct. Only people who have a piece of metal with a certain shape can open it.

So the limited vocabulary changed how you wrote?

As I wrote, I had tools that would warn me if I used a word that was not on the list, like a spell-checker. But much of our writing and speech is automatic and even on the last day of writing I used the word "astronaut" without thinking and only noticed when the spell-checker thing kicked in. Having the rules was nice because every sentence or two it would just poke me in the side and say, wait, can you think of another way to say that? The constraint forces you to be more creative.

PROFILE

Randall Munroe is a former NASA roboticist and creator of the cult webcomic *XKCD*. His 2014 book *What If?* offered serious scientific answers to absurd hypothetical questions. His new book is *Thing Explainer: Complicated stuff in simple words*



Photographed for New Scientist by Ken Richardson



Did writing this book make other writing seem overly complex?

It definitely made me notice more when I came across complicated words. I read a paper recently about surveying a moon from an orbiter and it said they detected a number of lacustrine depressions. I looked it up and it means lake-like. So what they mean is, we've discovered some lakes. Of course, there's some value in not using familiar terms because you

"I did a comic about a Linux command that became the most popular thing I'd done"

want people to realise they are not exactly lakes. But at the same time, fluid-filled lacustrine depressions is the most complicated way to say "lake" I can imagine.

Is this an issue with how science is presented?

The bigger problem isn't so much the jargon itself, but the fear behind the jargon, the imposter syndrome. I have that feeling all the time. Like anyone, I have that desperate fear of sounding dumb and I think that makes it harder to communicate than it needs to be. It can make people use jargon.

Explanation seems to be at the heart of your work, including your XKCD comics...

I'm a chronic explainer at heart. I try to keep from going overboard on that, especially in everyday conversation. But you can't write a daily comic without encouraging a desire to take things from your head and push them at other people.

You used to be a roboticist. How did you end up creating webcomics full-time?

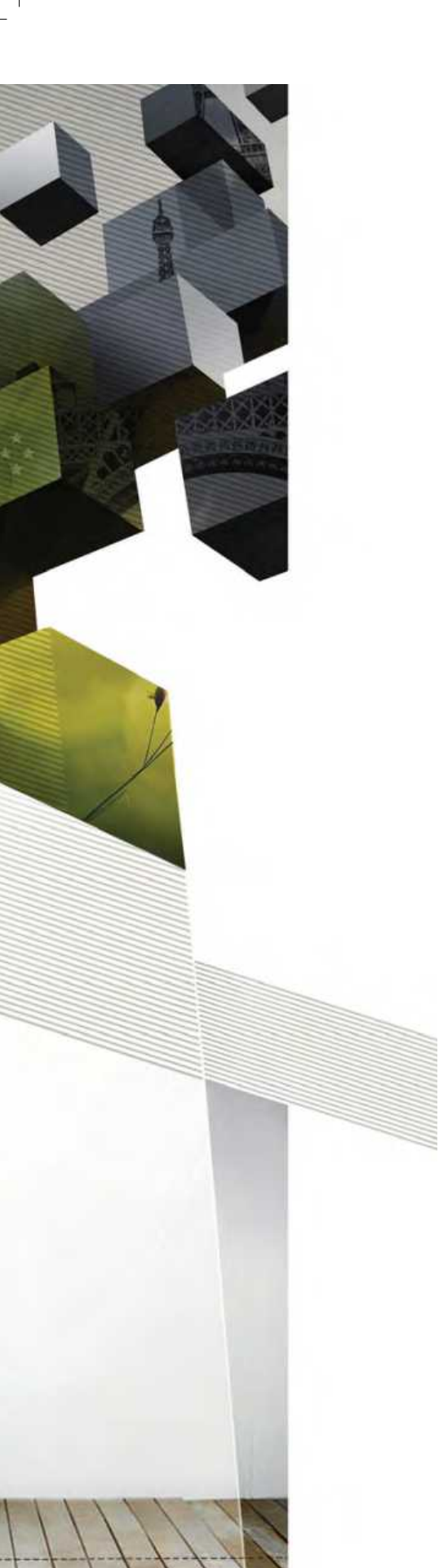
I grew up reading *Calvin & Hobbes*, which mixed childlike games with some dark, brooding ideas about the world. Charles Schulz's *Peanuts* did that too. I thought if I'm going to do comics, they need to talk about life in that way. Then I did a comic about a Linux command and it became the most popular thing I had ever done up to that point. It turns out you can talk about specific interests and there are lots of people who feel the same way about them. If it's interesting to me, there's probably someone else out there who's interested too. ■

Interview by Douglas Heaven

Win! We have five signed copies of Randall Munroe's book *Thing Explainer* to give away. To enter visit bit.ly/NS_xkcd



SKIZZOMAT



Shadows of the past

Clare Wilson goes on a quest to discover how we create memories and how they create us

IN THE Harry Potter films, they are silver streams that can be teased from the head with the tip of a wand. In the recent Pixar movie *Inside Out*, they are small glowing balls, stored in vast racks of shelving in our minds. But what does a memory really look like? How does your brain take information from the outside world and cache it for later retrieval? Where are your brain's storage vaults, what do they look like and how do they work?

A lot of us would be intrigued to know the answers to such questions – yet they are surprisingly hard to come by. Memory researchers have often seemed to take a piecemeal approach. Some focus on the minute details of what goes on in connections between brain cells. Others try to understand the subjective experience of memory – such as how, for Marcel Proust, the taste of a madeleine cake invoked detailed scenes from his childhood. However, they seldom consider the bigger picture of how the brain changes when we create a new memory.

Yet surely the answers must be out there – so I began a quest to find out what a memory really looks like. My aim was to see what goes on inside my head when I relive an experience or recall a fact but I also discovered a lot more. Memories, it seems, are the ghosts in the machine that make each of us unique.

Some early seminal work on memory was

done in the 1960s on sea slugs. These creatures grow up to a foot long and have giant nerve cells to match. Their outsize bodies make it possible to watch what happens when a new memory forms.

Ordinarily, electrical impulses in one neuron spark the release of chemicals that cross the gaps, or synapses, between nerve cells and may trigger a second neuron to fire. Those early studies revealed that when sea slugs learned a simple response to a stimulus some of their synapses were strengthened. An impulse in the first neuron was now more likely to trigger the second to fire (see diagram, page 38). This turns out to be the basis of memory in any animal with a nervous system. The work was so pivotal it earned neuroscientist Eric Kandel of Columbia University in New York a Nobel prize in 2000.

But it doesn't answer my question. The human brain contains an estimated 100 billion neurons, each thought to connect with, on average, 1000 others. That gives us something like 100 trillion synapses. When I create a memory, which of those synapses are strengthened?

A major step along the route to answering this question came from one of the saddest tales of modern neuroscience. In 1953, Henry Molaison – known for a long time only by his initials, H.M. – had an operation that went ➤

badly wrong. The surgeon had been trying to remove brain tissue that was causing his epilepsy. Molaison's seizures originated in the hippocampi, a pair of structures, either side of the brain, whose Latin name reflects their supposed resemblance to a seahorse. So the surgeon took them out.

The consequences for the 27-year-old Molaison were huge. Unable to hold a thought in his head for long, he needed care for the rest of his life (see "Groundhog day every day", page 39). But equally profound was the impact on neuroscience – we have learned volumes from the way the surgery destroyed some of Molaison's abilities but spared others.

Molaison seemed to retain most of what he knew before the operation, suggesting that while the hippocampi are crucial for forming new memories, they are less important for storage. His short-term memory was unaffected, too – he could retain information for 15 to 30 seconds but no longer. In addition, Molaison's brain damage revealed that there are some important subdivisions of long-term memory (see "Hold that thought", right). He could still learn physical skills, like riding a bike. But he had problems forming new memories of things that happened to him and learning new facts.

The long and short of it

The hippocampi seem to be crucial, then, for the sort of memories that are central to our personal and intellectual lives. So I go to meet Hugo Spiers, a neuroscientist at University College London who has made a career of studying them. In his office is a life-size rubbery model of the human brain. While he is making me a cup of tea, I pick it up and pop out one of the hippocampi. For something so vital, it's rather underwhelming – and disappointingly unlike a seahorse. In fact, it's about the size and shape of a chipolata – an unlikely seat of human learning and mental time travel.

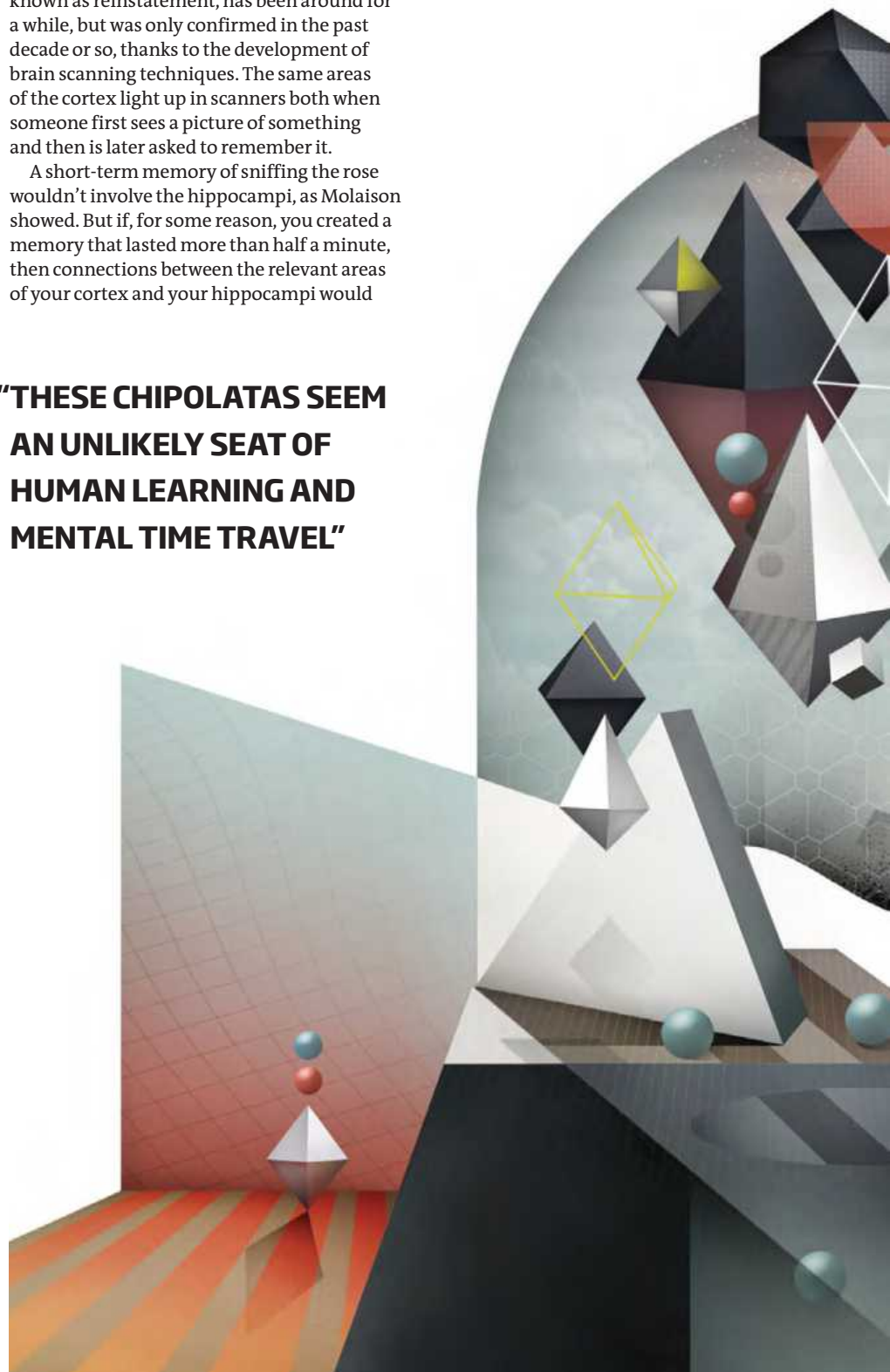
Spiers puts me straight. They are by no means the only part of the brain required to make a memory, he says. While the hippocampi are important and dominate current research, memory also involves the cortex, the outer layer of the brain that handles our complex thoughts and sensory perceptions of the world.

Say that yesterday you saw a rose in your garden and stopped to inhale its fragrance. This event was processed by specific parts of your cortex at the brain's back and sides that are responsible for vision and smell. Today, if

you recall the experience, those same regions will be reactivated. This idea, sometimes known as reinstatement, has been around for a while, but was only confirmed in the past decade or so, thanks to the development of brain scanning techniques. The same areas of the cortex light up in scanners both when someone first sees a picture of something and then is later asked to remember it.

A short-term memory of sniffing the rose wouldn't involve the hippocampi, as Molaison showed. But if, for some reason, you created a memory that lasted more than half a minute, then connections between the relevant areas of your cortex and your hippocampi would

**"THESE CHIPOLATAS SEEM
AN UNLIKELY SEAT OF
HUMAN LEARNING AND
MENTAL TIME TRAVEL"**





HOLD THAT THOUGHT

SHORT-TERM OR WORKING MEMORY

involves retaining information for up to 30 seconds – long enough to dial a phone number, for instance – before it is forgotten. Short-term memory generally involves neuronal networks in the cortex, the outermost part of the brain.

LONG-TERM MEMORY involves holding information for longer than half a minute. It splits into **IMPLICIT** and **EXPLICIT** memories.

IMPLICIT (PROCEDURAL) MEMORIES are long term-memories involved in learning new physical skills, such as playing an instrument.

EXPLICIT (DECLARATIVE) MEMORIES are long-term memories we are aware of and can talk about. To create them, neurons in the cortex must activate others in the hippocampi, two structures deep in the brain.

Explicit memories take two forms: **AUTOBIOGRAPHICAL** and **SEMANTIC**

AUTOBIOGRAPHICAL (EPISODIC) MEMORIES are of specific events from our personal history, such as eating with a friend yesterday.

SEMANTIC MEMORIES relate to facts. They are thought to start out as autobiographical – we remember where and when we learned the fact. They then become semantic with repetition – we forget the personal context and just retain the fact.

become strengthened. The hippocampi are wired up to many different parts of the cortex and help to glue together the different aspects of a single memory, says Spiers.

In fact, their role was beautifully illuminated this year. Researchers scanned people's brains as they tried to learn groups of unrelated concepts – such as Barack Obama with a wallet in a kitchen. They found that recall was best for those groups of concepts that had generated the most activity in their hippocampi during the learning phase. "The hippocampus allows you to retrieve all the elements together," says psychologist Aidan Horner at University College London, who did the study.

This ability helps explain one of memory's hallmarks – that recalling one aspect of an experience can bring its other features to

mind unbidden. Hearing a song on the radio can remind us of the moment we first heard it, for example, or a long-forgotten taste of madeleine cakes can remind you of childhood. "It's almost as if we re-experience it," says Horner.

Intricate webs

I'm starting to get a picture of a memory as a discrete physical entity, a spider's web of silvery neurons firing together because of their strengthened connections, with strands reaching across different parts of the cortex and deep down to the hippocampi, guardians of our memory bank.

Yet something is still puzzling about the hippocampi. Research in rats and mice has shown they are crucial for navigation, with the structures sometimes even called the brain's satnav. By placing electrodes in the animals' hippocampi to see the activity of individual neurons, researchers discovered cells that fire only when an animal is in a certain location. These neurons are called place cells. Which combinations of these cells are firing can tell you where the rodent is to within 5 cm². "When the rat runs through a maze, you can see the cells fire in sequence," says Spiers. "Just through the rat's place cell activity, you can decode where it is – you're reading the rat's mind." He and others have found that the same place cells even fire when the rats are asleep, suggesting we are reading their dreams.

So how come long-term memory and navigation seem anchored in the same brain region? As Spiers sees it, navigation must have come first. "Every single moving animal that has to acquire food cares about the 'where' above all things," he says. Then, as mammals developed more complex intellectual lives, the hippocampi were co-opted into an all-purpose mechanism for anchoring any important event into our memories. "A grid system is a beautiful system for mapping lots of things on to," he says.

That's a fairly speculative idea, but it does have some support from work with people who have epileptic seizures originating in their hippocampi, as Molaison did. Nowadays only one hippocampus is ever removed. "And we always check the viability of the other hippocampus first," says neurosurgeon Itzhak Fried at the University of California, Los Angeles.

To pinpoint the problem area, patients often stay for a couple of weeks in his clinic with up to 100 electrodes in their



You must remember this

Memories are laid down in the form of strengthened connections between nerve cells in the cortex and the hippocampi

Cortex

Neurons in the brain's outer layer process our sensory perception. They will be reactivated if we later remember that experience

Hippocampi

These brain regions bind together separate concepts into a single memory

Neurons

Memories strengthen connections between neurons, making one more likely to trigger another

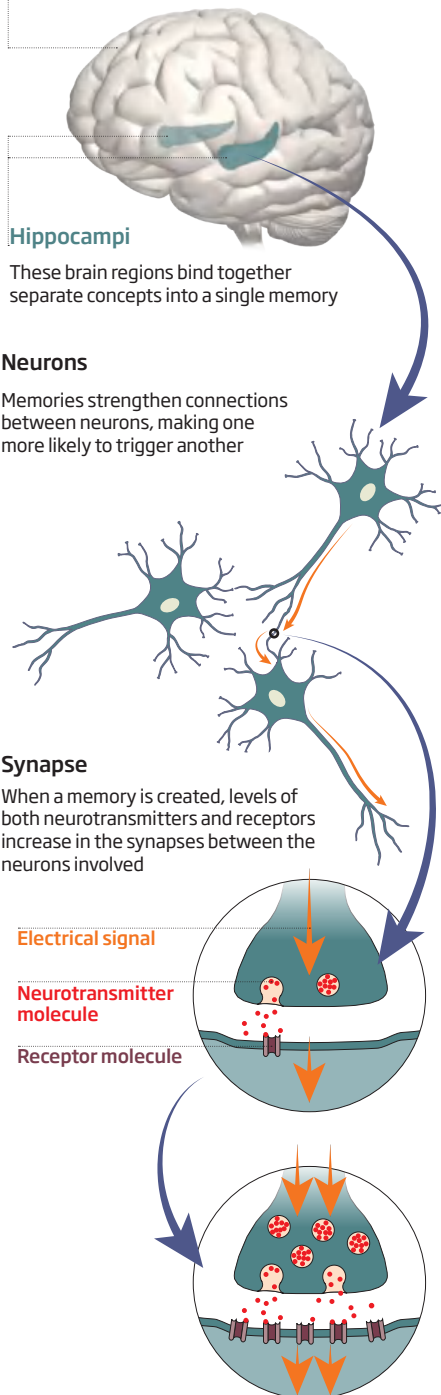
Synapse

When a memory is created, levels of both neurotransmitters and receptors increase in the synapses between the neurons involved

Electrical signal

Neurotransmitter molecule

Receptor molecule



hippocampi. Thanks to them we have discovered that, just as neurons in a rat's hippocampi fire only when the animal is in a specific place, so those in the human hippocampi fire only on recognising a certain thing. That could be a place but it could also be a person, an object or almost anything.

Fried's team popularised this idea in 2005 with the catchy notion of "Jennifer Aniston neurons", because one of their first patients happened to have an electrode placed next to a neuron that fired in response to pictures of the actor. But I thought that recognising people is the job of the visual cortex. So how does that tie into neurons in the hippocampi firing?

Jennifer Aniston

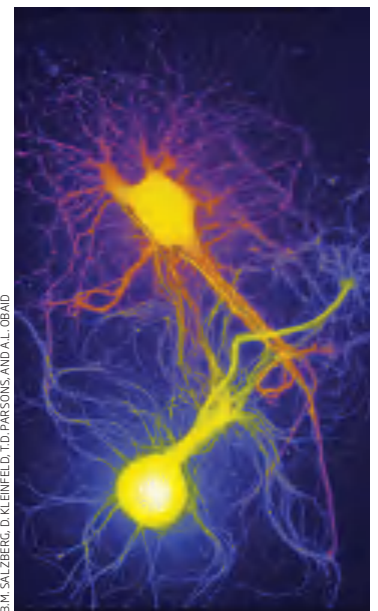
It all makes sense once I speak to Rodrigo Quijan Quiroga at the University of Leicester, UK, who works with Fried. Different cells in the visual cortex are great at recognising the actor under different conditions – side on, with different hairstyles, under low lighting and so on. The hippocampi Aniston neurons, on the other hand, don't care about what she looks like; with them it's binary – she's either there or she isn't. They even fire when her name is spoken or written. "It's an abstract concept," says Quijan Quiroga.

Here's how the two systems mesh: to form a lasting memory of seeing Jennifer Aniston on a particular occasion, the cortex neurons must fire up the hippocampi concept neurons. If you bumped into her while sightseeing at the Eiffel Tower, your hippocampi Aniston neurons would start firing at the same time as your hippocampi "Eiffel Tower neurons". That would strengthen the connections between them, helping to create a lasting association. At least, that's the theory, says Quijan Quiroga. He and Fried have found some supporting evidence: when their patients with electrodes implanted in their brains were shown photoshopped pictures of Aniston in front of the Eiffel Tower, their Aniston neurons started to fire in response to pictures of the Eiffel Tower alone.

It's almost as if Quijan Quiroga and his team are witnessing the birth of new memories in the brain. They may even be edging towards an answer to the question of how many neurons are involved. To do this they had to start with a couple of estimates: that there are about 1 billion cells in a human hippocampus and that we can recognise at least 10,000 different concepts, such as places, objects, friends or celebrities. When they showed a random selection of pictures representing such



SUZANNE CORKIN



B.M. SALZBERG, D. KLEINFELD, T.O. PARSONS, AND A.L. OBADI

A single concept may be represented by 1 million neurons in your hippocampus



GROUNDHOG DAY EVERY DAY

What would it be like to have no long-term memory? The case of Henry Molaison, whose memory was damaged irreparably in 1953 after brain surgery for his epilepsy, gives us some clues.

Unlike the amnesiacs of movies, H.M. (as researchers called him) knew who he was, because he had retained most of his memories from before the operation. But he could hold no new information for more than half a minute. Researchers would have the jarring experience of him failing to recognise them after they had nipped out of the room for a moment.

If he saw his reflection, Molaison was often surprised by how old he looked. When his parents died, he forgot even that. Yet most of the time he seemed not frightened or confused but happy and good-natured. He often expressed a wish to further the cause of medical research and never tired of being tested. "He was always happy to

help," says neuroscientist Suzanne Corkin at the Massachusetts Institute of Technology, who worked with him for nearly five decades.

As Corkin describes in her book, *Permanent Present Tense*, interactions with Molaison could verge on the surreal. On one car journey to the research centre, Molaison was sitting in the back seat when he noticed a McDonalds coffee cup on the dashboard. "Hey, I knew a fellow named John McDonald when I was a boy!" he said, and proceeded to tell a few stories about what they had done together. A few moments passed with Molaison looking out of the car window. Then he noticed the cup again. "Hey, I knew a fellow named John McDonald when I was a boy!" he said, and repeated the same tales, almost verbatim. Only minutes later, he did the same thing again. At that point, the researcher discreetly threw the cup under a seat.

concepts to their patients, they discovered that each neuron had about 0.1 per cent chance of firing in response to any given concept. This suggests that each concept is encoded by about 1 million hippocampi neurons.

In theory then, a memory of meeting Aniston at the top of the Eiffel Tower on my birthday should involve three different concepts and therefore some 3 million neurons in the hippocampi, according to Quian Quiroga. Wouldn't it also involve cells in the cortex – cells representing everything from my emotions and what I was wearing that day, to the sound of Aniston's voice? Perhaps, says Quian Quiroga, but not always. He points out that often our memories lack such details. "A skeleton of a memory is not as rich as we think," he says.

If he's correct, then my imagined silvery web of a memory with strands attached in the cortex and hippocampi changes with experience. As my memory of Aniston is adjusted, new links are made to the neurons in the hippocampi connected to Paris, and over time others are perhaps weakened.

I like this idea of memories as collections of concepts because it suggests they have a bigger role as the building blocks of thought. After all, how could I have thought about whether I wanted Spiers to make me a cup of tea when I was in his office unless I had the concept of tea, the memory of drinking it, and of liking it, stashed away somewhere? Talking about thoughts is too speculative for Spiers's liking, though. "They are a nebulous concept," he says.

But others are more willing to follow this line of thinking. They include Demis Hassabis, who leads Google's Deep Mind artificial intelligence venture and researches human memory in the hope it will inspire better

artificial intelligence. He has found that people with damage to their hippocampi have as much difficulty imagining future events as recalling past ones, suggesting that memories play a significant part in the way we formulate thoughts. Breaking down the world into its underlying concepts may not just be the way that we think about the past, Hassabis says, but also the present and the future.

It could even help us understand creativity. "If that's how memory works, then imagination must rely on the same processes," he says. "You're still pulling together components but in this case in a novel way." In that case, the way your memories tie together concepts and allow you to imagine things and plan your future defines you in an inescapable way. Without them, you couldn't desire a cup of tea, or dream up your perfect holiday.

So is it my memory that makes me me? I put the question to Hassabis. "Memories are core to ourselves and our personalities," he says. "It's a cliché that's also somewhat true – we are just the sum of our memories." ■

Clare Wilson is a medical reporter for *New Scientist*

"MEMORIES ARE NOT JUST ABOUT THE PAST, BUT THE PRESENT AND FUTURE TOO"



The dragon morphs

China's energy use and carbon emissions have skyrocketed in recent years, but the nation is not the eco-sinner it once was, says Deborah Seligsohn

FIRST arrived in Beijing in 1984. The winter was bitterly cold. We routinely wore three pairs of long johns under our jeans, tops and sweaters, then added a bulky overcoat to go outdoors. What meagre heating we had was only on for four months of the year, even though Beijing hovered below freezing for almost six. It was also dark. One of my students cheerfully informed me it was “Save electricity Tuesday”, which was always followed by “Save electricity Friday”. These were rolling blackouts, when electricity was switched off across the neighbourhood for the entire day – even in factories, which meant no one worked twice a week.

Despite the lack of warmth, light and transportation, Beijing was horribly polluted, especially in winter. Buses belched black smoke. When I rode my bike through city streets I'd often find chunks of coal in my hair, coughed up by the boilers of the surrounding houses. It was a full year before I knew that the Western Hills should be visible from right outside the Beijing Normal University, where I was employed as teacher.

Fast-forward to today, and Beijing is a changed city. People's lives have been radically transformed. The Western Hills are now visible at least half the time. Beijingers live in modern apartments with warm water, televisions, refrigerators and washing machines – all the usual trappings of modern life. This lifestyle has come at the cost of a huge rise in energy consumption, most of it generated by coal-

fired power stations. Not only is China now the largest overall energy consumer in the world, it has surged ahead to become the biggest emitter of greenhouse gases. But as representatives from 195 nations gather in Paris for a crucial round of UN climate talks next week, it's worth exploring a different side of the story.

Peer behind the curtain and you get a more nuanced picture than the usual stats suggest. A remarkable change is now taking place in China. Quietly, over the last decade, it has turned its factories around, with a view to cleaning up the skies above. China is no eco-saint, but it has recognised the enormous benefits of using fuel more efficiently. After the massive growth of the last 15 years, its emissions are starting to slow. It's still early days, but China's coal use has already peaked, and a greenhouse gas peak may not be far behind.

2007/08 China becomes the world's biggest emitter of greenhouse gases

No one – not even China – expected its emissions to shoot up quite as fast as they did. When, in 2007, the Netherlands Environmental Assessment Agency suggested that the country had become the world's top emitter, the news came as a surprise to all. It was several years earlier than anticipated – so much so that the figure was disputed. ➤

2010

China becomes the world's biggest energy consumer

The International Energy Agency confirmed the trend in 2008. In 2010, China became the world's largest energy consumer, about five years earlier than expected. And in 2014, the Global Carbon Project reported that its emissions per capita exceeded those of the European Union. The figure is an average. Germany's per capita emissions, for instance, are still higher than China's; those of other EU nations, like the UK and France, are now lower. This rapid rise in emissions – compounded by China's huge population, which amps up any stats about it – is why the country is often described rather simplistically as the world's largest polluter.

How to control emissions is at the heart of the UN climate talks. There are two main ways of doing this: you can cut the amount of fossil

installed wind power than any other country, and each year adds more than everyone else. It is also second in installed solar capacity.

The country gets nearly a quarter of its electricity from hydropower, and that share will continue to grow for another five to 10 years until prime locations are all taken up. Hydropower is often criticised for its environmental cost, but it is worth remembering that the dam-building we are seeing in China today is following the same path as it did in Europe, the US and Canada in the last century.

Solar, wind and hydro – plus a small but growing portion of nuclear power – are paving the way for a future that relies less on coal. In 2014 it accounted for 65 per cent of China's energy use, down from 70 per cent in 2011. While the trend is encouraging, the figures show that so far, alternative fuels have only had a small impact. The real way China is controlling its emissions is less photogenic than a solar array, but much more potent.

Like many developing nations, 20th-century China was far from energy-efficient. What little heating and electricity we had in our spartan 1980s apartments came from inefficient coal boilers. Those used in power stations were actually dangerous. They were known to blow up, killing workers, if the pressure was raised to boost efficiency. The government responded by buying and developing new, safer, more efficient technology – a good start, but the breakneck pace at which China began transforming itself in the 2000s meant that these initial efforts paled into insignificance compared with the sheer quantity of energy being used. In 2006 the government renewed its efforts by

declaring “energy efficiency and pollution reduction” a national priority and bringing in new programmes to target industry.

Researchers in Lawrence Berkeley National Laboratory's China Energy Group have shown that real improvements came primarily from two major programmes launched in the 2006-2010 five-year plan that had almost equal importance. The Thousand Enterprises Program took China's top 1000 companies and forced them to completely rethink their energy use. Companies were told to appoint staff to monitor energy efficiency and upgrade, redesign and replace industrial kit and software – all with the aim of becoming more energy-savvy, cutting the amount of power they used without denting productivity.

Peak emissions

The second programme was more drastic. In order to cut energy waste, thousands of small and inefficient industrial units across the nation – factories, assembly lines – were simply told to close down. In most cases, companies shut old, dirty installations and shifted operations to newer ones. Remember that China's economy was booming at the time. For the most part workers either shifted within the same company or looked for opportunities in the exploding economy.

Both programmes targeted steel, cement, power, paper and other energy-hungry industries. They were so successful that they were extended in the next five-year plan. The Thousand Enterprise Program became the Ten Thousand Enterprise Program. Smaller and more inefficient plants continued to shut up shop.

The efforts have borne fruit. In the first five years, China cut energy intensity – a measure of how much energy is used to generate \$1 of GDP – by 19.1 per cent, missing its ambitious 20 per cent goal by a hair's breadth. This was a victory in my eyes, both because the figure was much higher than outsiders predicted, and because it showed China would be honest about its achievements even when it didn't quite meet its goals. The goal of the current five-year plan is to reduce intensity by another 16 per cent, and all indications are that this will be met. The government has also set a carbon intensity target to cut the amount of carbon emitted per unit of GDP by 17 per cent. This

2014

Chinese coal use drops for the first time

fuels you burn and you can stop deforestation. China is, in fact, a major reforester. Forest cover has grown from 8.6 per cent in 1949 to more than 20 per cent today. And while there are debates about how much carbon each new acre of trees captures, and concerns about the biodiversity and health of China's new forests, increased tree cover has undoubtedly soaked up a great deal of carbon that would otherwise be in the atmosphere.

Most of that carbon comes from coal – the dirtiest of fossil fuels – but the country has also made a huge effort to boost other sources of power. Figures from the Global Wind Energy Council show that China now has more

China is second in the world for installed solar capacity



IAN TECH/PANOS

#1

China has more installed wind power than any other nation



One fifth of China is forested, up from 8.6% in 1949

was a goal promised at the Copenhagen climate talks in 2009.

It takes a long time for energy policies to produce major results, but China is now clearly committed to a lower carbon future. In the last 12 months, it has said that its emissions will peak by 2030 or earlier if possible. It is difficult to overstate the importance of this peak for the future of the planet, especially when we're talking about the world's biggest emitter. Even though developing nations still need room to grow – meaning their emissions will continue to rise in the short term – temperatures simply cannot be kept in check if global emissions keep on growing year after year.

While the Chinese never explicitly say they are responding to the emissions data, they do describe themselves as under increasing pressure. The pressure is not just to cut emissions in response to the international community, but also to clean up its air and water to improve public and environmental health. China is still in many ways a developing country, but it has also clearly recognised its responsibility to be a world leader.

And here's the surprising aspect of the Chinese growth model. The country's emissions rose faster than anyone expected, but the reverse may also come to pass. Emissions are still growing, but they are rising a little less with each passing year, which suggests China is in fact rapidly approaching its peak. Coal consumption actually dropped for the first time ever in 2014, according to the China's National Coal Association. Some say the drop is due to an economic downturn. But a number of economists argue that the slowdown in China's traditional industrial sector has been matched by a rise in the services industry – a shift towards low-carbon sectors that would be good news both for the

economy and, crucially, for global emissions.

Certainly on the ground in China things appear quite prosperous. Where, in the 1980s, you had virtually no transport between even the major city hubs, today you have access to fantastic subway systems, high-speed rail that connects virtually the entire country, city and inter-city bus systems, a comprehensive air network, over 200 million electric bicycles, and over 150 million private cars. High-speed rail is gradually replacing air travel on shorter routes – a huge carbon saving.

The general consensus among climate change analysts is that China is now approaching its emissions peak surprisingly fast because it is moving away from an economy that is primarily driven by industry.

65%

Proportion of energy that comes from coal, down from 70% in 2011

Jiang Kejun, one of China's foremost energy modellers at the government-run Energy Research Institute, argues the country can peak as early as 2022. Within China, there is a healthy debate on the subject, but the consensus is that a pre-2030 emissions peak is quite possible.

Recently, in a remarkable Joint Presidential Statement with the US, China also committed to setting emissions targets for various sectors, and to getting a cap and trade market – where polluters may trade the right to emit – off the ground by 2017. Some of the planning for the cap and trade system is impressive. The design process is mainly about how to allocate carbon credits to industry. Zhang Xiliang of Tsinghua University in Beijing, who is part of the design team, says credits are being given only to factories that operate above a

2022

When Chinese emissions could begin to drop, ahead of the official 2030 target

benchmark level of efficiency. Others will need to purchase them, which should help close down even more top polluters, for whom the cost will be too much to bear.

Whether carbon markets will be the best solution for China is an open question. Both Jiang and Yang Fuqiang of the Natural Resources Defense Council, a US NGO, believe it will ultimately implement a carbon tax. The Chinese government is good at collecting taxes, and does not have to deal with the same political opposition to taxation as the US and Europe. Which solution it opts for is essentially a technicality. The bottom line is that it has a number of tools to control emissions and an economy that is changing in ways that help with further cuts.

This brings us to the next milestone – the talks in Paris, which begin on 30 November. This round is significant: at stake is a long-term agreement to curb global emissions. Existing climate agreements cover emissions up to 2020, but governments have pledged that by close of business on 11 December, they will have a document setting out concrete steps for addressing the climate crisis beyond that date.

As China has become wealthier, and daily life more like that in many developed countries, especially for the half of the population who live in cities, the country has also forged more connections with the rest of the world. Thirty years ago, Chinese policy was highly insular. Today its scholars are major players in drafting the assessments that inform climate talks, and its negotiators are playing an increasingly active role too. Many of those I've spoken to talk of China's potential to be a leader in Paris. They say the presidential statement, which was issued in September, could form the basis for agreements. They also point out that China's commitment of \$3.1 billion to help developing nations cope with climate change is slightly more than the US promise of \$3 billion. This, they say, is reinvigorating talks about financing the fight against climate change.

It's far from an even picture. Pollution and especially protecting the environment are still enormous challenges for China, but on climate change it appears to have turned a corner. ■

Deborah Seligsohn is a researcher at the University of California, San Diego, and former Science Counselor at the US embassy in Beijing

A turkey is not just for Thanksgiving or Christmas – it's a bird with a noble history and a bright future, finds Lesley Evans Ogden

Return of the native



W E HUMANS have a fondness for calling someone or something we consider inept a “turkey”. Could turkeys talk, they might be inclined to throw the insult back the other way.

Ecologist Michael Chamberlain of the University of Georgia has witnessed the bird's ability to outsmart people at first hand. He was in the field tracking a mother turkey and her poults. Thanks to the micro-GPS units he co-developed, he knew their exact whereabouts, and sent a fieldworker into the forest to find them. His colleague walked around for almost an hour trying to track them down, and never once spotted them. Chamberlain did, though. “I was sitting in the truck,” he says. Through the windshield, he saw the turkey sneak across the road with her brood, right in front of him. The fieldworker had been behind her the whole time, but she was clever enough to keep out of sight.

“Smart” isn't a word most of us associate with the bird that graces many a Thanksgiving and Christmas dinner plate. Yet it is the domesticated cousin of the wily wild turkey, *Meleagris gallopavo*, which without its guile might well have gone the way of the passenger pigeon. However, in a heart-warming success story for conservation, this native American has made it back from the brink of extinction. Better yet, while many other species are feeling the heat of climate change, the wild turkey is going from strength to strength.

Turkeys are native to North and Central America, with six regional subspecies. Although domesticated by the indigenous peoples of Mesoamerica some 2000 years ago, the wild variety was an important resource for many Native American peoples, not just for its meat and eggs, but also for feathers, bones and spurs, which were used to make clothing,

TALKING TURKEY

- Wild turkeys will eat anything from flowers to salamanders, but acorns are a firm favourite.
- Turkeys are sophisticated talkers with separate alarm calls for “ground predator!” and “aerial predator!”
- The average clutch size is 11 but hens lay eggs in each others' nests, so one female can incubate up to 26.
- Male turkeys are known as toms or gobblers. Females don't gobble.
- The pendulous flesh hanging down over a male's beak is called a snood.



Wild turkeys need trees to roost in, which a century ago was almost their undoing

spoons, musical instruments, arrow tips and more. Estimates put the wild turkey population before Columbus arrived at some 10 million, though no one was counting. Around 1600, when Europeans first began settling in North America, the wild birds were so abundant they could be seen in flocks of hundreds.

Ironically, early settlers brought domesticated turkeys with them – these were the descendants of Mesoamerican poultry that had been introduced to Europe by earlier explorers. But turkey farming was small-scale and settlers soon learned that wild turkeys were good tucker and easy prey, owing to their habit of roosting in large groups in trees. Turkeys became so established in the pioneer psyche that in 1784, commenting on the choice of the bald eagle as the national bird, Benjamin Franklin quipped: “The turkey is in comparison a much more respectable bird, and withal a true original native of America...

Tracking devices have revealed the wild turkey to be a wily and adaptable bird



He is besides, though a little vain and silly, a bird of courage, and would not hesitate to attack a grenadier of the British Guards.”

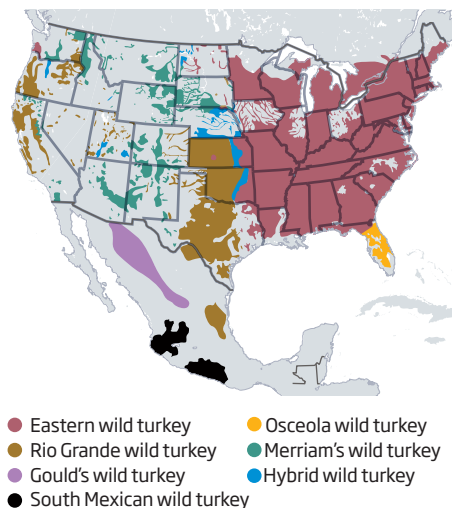
Despite such affection, the hunting of wild turkeys continued unregulated. And the birds faced another threat, too. Turkeys aren't particular about where they live, but they do have one requirement: trees. As settlers crossed the country, logging for timber and clearing forest to create farmland, suitable turkey habitat diminished. All this unfettered felling and trapping meant that by the end of the 19th century – around the time that passenger pigeon populations began to plummet – the wild turkey was in trouble. By 1920, it had been eradicated in 18 of the 39 states it had once occupied, and had also disappeared from Ontario, Canada.

Estimates of the population size at its nadir range from 30,000 to 200,000. Yet, as the passenger pigeon was sucked into the vortex of extinction, concern arose about the disappearance of wild turkeys. This was especially fervent among those who liked to hunt them, and efforts were launched to bring the birds back from the brink. In 1937, these came to fruition when a new excise tax on guns and ammunition generated revenue earmarked for wildlife management and restoration. The wild turkey was to get a share.

Armed with conservation dollars, wildlife agencies in several US states began collecting turkey eggs from nests in the wild, bringing them into captivity to rear for later release. Two decades of time and money later, nothing had changed. Almost all of the efforts were “dismal failures”, says Tom Hughes, a biologist with the National Wild Turkey Federation – most of the young turkeys didn't survive once released. “They hadn't grown up under the direction of a wild hen,” says Hughes, so they

Where gobblers roam free

A century ago, wild turkeys were almost extinct. Today there are over 6 million, divided into six subspecies, plus a hybrid



had no idea how to behave in the wild. “They didn't know what to avoid. They didn't know what to look for.”

By 1960, most wild turkey breeding had been ditched. Instead, wildlife agencies used spring-loaded rocket nets to capture whole flocks and relocate them to a suitable turkey-free habitat. Bingo! Turkeys began spreading like wildfire. Able to adapt to new settings

“In a warmer world we can expect to see more of these canny birds”

before potential predators had learned to hunt them, they enjoyed a honeymoon period in many places that enabled populations to establish and thrive, says Hughes.

Fast-forward to today, and wild turkeys are abundant across the continent, with numbers estimated at over 6 million. One factor that limits their northward expansion is snow. “When the snow is really deep, turkeys can't move through it, and can't find their food,” says Britney Niedzielski. While at Trent University in Peterborough, Canada, she found that many wild turkeys don't survive the winter at the northern limits of their range. However, those hanging out near farms can often get enough spilt grain and corn to see them through.

And with a helping hand from climate change, wild turkeys are likely to spread further north, says Niedzielski. So, in a warmer world we can expect to see more of these canny birds... and fewer frozen ones. ■

Lesley Evans Ogden is based in Vancouver, Canada. On Twitter @ljevanso



These we loved...

This year's top cultural picks, from the future of AI to Russia's glorious space past and an aircraft carrier made of ice

SUMIT PAUL-CHOUDHURY, EDITOR

The Four-Dimensional Human: Ways of being in the digital world by Laurence Scott, William Heinemann, £20

My reading this year was largely prescribed by the Samuel Johnson prize, which I helped to judge. The submissions didn't include much pure science, but it was won for the first time by a science book: Laurence Scott's *The Four-Dimensional Human*. Most books on digital communication are either grumpy or evangelistic; Scott's is a thoughtful attempt to describe how it is altering the

Another shortlisted book may interest *New Scientist* readers: Laurence Scott's *The Four-Dimensional Human*. Most books on digital communication are either grumpy or evangelistic; Scott's is a thoughtful attempt to describe how it is altering the

human condition in ways both familiar and strange, drawing on everything from philosophy to pop culture along the way.

The resulting collage of ideas and images won't appeal to everyone. But Scott's book is a notable contribution to a strand of literature that needs to flourish.

GRAHAM LAWTON, DEPUTY EDITOR

The Ingenious Mr Pyke: Inventor, fugitive, spy by Henry Hemming, PublicAffairs, \$26.99

A welcome break from heavyweight must-reads, *The Ingenious Mr Pyke* is essential reading of a different sort. It's the tale of a true British eccentric, Geoffrey Pyke. He was an inventor, adventurer and

polymath who escaped from a German prison camp during the first world war, and launched his own bid to avert the second. He sent a group of interviewers disguised as golfers into Nazi Germany to check on the real views of the people.

In 1942, he even persuaded Winston Churchill to build an aircraft carrier out of reinforced ice. It was never built, though the plans were real enough. But along with the tales of derring-do, there's a big question: who was he really? Read it and find out. Sheer magic.

"It takes 2.5 seconds to process the present – also the time your social media feed needs to refresh"

JULIAN RICHARDS, ACTING DIGITAL EDITOR

Ex Machina, directed by Alex Garland, various formats

When movies take on science, science rarely survives. So I was surprised to find *Ex Machina* was all its fans had said: a gripping paranoid thriller, bouncing off key concepts in AI and consciousness. Not just the Turing test – it dismissed that early on – but questions about knowledge, experience and empathy, with Jackson Pollock paintings chucked in for good measure, and sexual perversity trowelled on before an ending that is... a victory? A disaster? The film's closing success is to leave us pondering.

LIZ ELSE, ASSOCIATE EDITOR/ CULTURELAB EDITOR

The Health Gap: The challenge of an unequal world by Michael Marmot, Bloomsbury, £20

I love books with a quietly revolutionary flavour. Michael Marmot's *The Health Gap* is welcome as a stealth takedown of the UK's passion for austerity. In

Clockwise from left: Matt Damon in *The Martian*; Joanna Newsom; LK-3 lunar lander; Alicia Vikander, *Ex Machina*; Alexander von Humboldt

the ironic spirit of “I come to bury Caesar, not to praise him”, his message about what the unequal distribution of wealth does to the health of us all is a distillation of decades of research, written for a reading public. Give it to any finance ministers you may know (or right-wing relatives).

STEPHANIE PAIN, CONSULTANT

The Invention of Nature: The adventures of Alexander von Humboldt, the lost hero of science by Andrea Wulf, John Murray, £25
Everyone’s heard the name. It’s dotted over half the world’s maps. But who knows why? Alexander von Humboldt was a scientific superstar, his life packed with adventures, discovery and a cast of 19th-century movers and shakers. Napoleon envied him his fame. Darwin was an ardent admirer. Read Andrea Wulf’s gripping biography and you will be wowed by him too. If Humboldt doesn’t win prizes I’ll eat my party hat.

ROWAN HOOPER, MANAGING EDITOR

Divers, Joanna Newsom, £9.99
Joanna Newsom has been called this generation’s Kate Bush but no one has a voice like hers, and no one plays the harp like her. Extraordinary and magical, and she sings about space and time, so she ticks all boxes really.

JACOB ARON, NEWS REPORTER

The Martian, directed by Ridley Scott (out on DVD in 2016)
The Martian is the latest in a string of “realistic” space films, following on from *Gravity* and *Interstellar*, and I hope there will be many more. The joy of seeing stranded astronaut Mark Watney, cleverly played by Matt Damon, scavenge every possible resource on Mars – including some you might not expect – in his quest to get home is only slightly spoiled



by the fact that we most probably won’t be visiting the Red Planet for real any time soon.

DOUGLAS HEAVEN, FEATURE EDITOR

TIS-100, developed by Zachtronics, £4.99 (on Windows/OS X/Linux)
For the frustrated hacker in your life. *TIS-100* is a puzzle game in which you rewrite corrupted code to unlock the secrets of titular computer and star of the show: the Tessellated Intelligence System.



Solving puzzles actually requires learning a made-up programming language. Comes with a handy 1980s-style reference manual to pore over. A perfect brain workout.

SIMON INGS, CULTURELAB EDITOR

The Age of Earthquakes: A guide to the extreme present by Shumon Basar, Douglas Coupland and Hans Ulrich Obrist, Penguin, £9.99
Are your older relatives losing the plot? Are you? Then *The Age of*

Earthquakes is for you. Critic Shumon Basar, novelist Douglas Coupland and curator Hans Ulrich Obrist explore “the extreme present”, where the future is apocalyptic and the past no longer remembered, just uploaded onto Swedish server farms. Did you know that the time it takes your brain to process the present – 2.5 seconds – is also the time your social media feed needs to refresh, and also the average time gallery visitors spend looking at an artwork? Contains cat memes.

DEBORA MACKENZIE, CONSULTANT

Gut by Giulia Enders, Scribe Publications, £14.99
The Good Gut by Justin and Erica Sonnenburg, Transworld, £14.99
Two fun books about guts would make great presents, even for people who are not especially scientific. For the youngster fascinated by excreta (or just the body’s inner workings), *Gut* by Giulia Enders is an amazing romp down our alimentary canal. For new or prospective parents mired in a morass of advice, *The Good Gut*, by scientist parents Justin and Erica Sonnenburg, has the lowdown on giving a baby’s all-important gut bacteria the best start in life.

MICK O’HARE, EDITORIAL PRODUCTION EDITOR

Cosmonauts: Birth of the space age, Science Museum, London, until 13 March 2016

The most comprehensive collection of Soviet space hardware and artefacts from the 1950s and 60s ever gathered together continues to wow visitors to London’s Science Museum. The Christmas holiday season would be an ideal time to see what senior curator Doug Millard describes as “the Russian equivalent of the crown jewels”. From Yuri Gagarin through Valentina Tereshkova via Alexei Leonov, and from Sputnik to Salyut, the Soviet Union’s astonishing contribution to the space race is unmissable. ■

TWENTIETH CENTURY FOX FILM CORPORATION; TABATHA FREEMAN; GETTY IMAGES; STATE MUSEUM AND EXHIBITION CENTRE ROSIZO; DINA FILMS / FILM4; PHOTOSHOT; ULLSTEIN BILD; GETTY IMAGES; STATE MUSEUM AND EXHIBITION CENTRE ROSIZO

A year in books

In 2015 the future was everywhere. Enjoy **CultureLab's** best reads

1 Einstein's Dice and Schrödinger's Cat: How two great minds battled quantum randomness to create a unified theory of physics by Paul Halpern, Basic Books, \$27.99

In the centenary of general relativity, Albert Einstein and Erwin Schrödinger are celebrated in a book framing the contributions of both: Einstein for his theories of relativity, the photoelectric effect and his explanation of Brownian motion; Schrödinger for his wave equations explaining quantum objects' behaviour. Unusually, Paul Halpern also looks at their post-glory days, when the two spent longer on fruitless attempts to unify quantum physics and relativity than on their breakthroughs.

2 Seven Brief Lessons on Physics by Carlo Rovelli, Allen Lane, £9.99

Feeling daunted by even attempting to scale Mount Einstein? This Italian bestseller, now translated into English, may be for you. Physicist Carlo Rovelli pulls off the trick of vividly capturing everything from elementary particles to dark matter in 78 pages. It's not just for novices: there are also heady pages on loop quantum gravity.

3 The Vital Question: Why is life the way it is? by Nick Lane, Profile, £25

No physics envy here, just biology vast in scope and ambition, brimming with bold ideas and questions. They don't get much bigger than these: why did complex cells evolve just the once, how did life first evolve, what would life be like on other planets, why do we age? This is incredible, epic stuff, beautifully done and likely to transform the way we look at the world.

4 How to Clone a Mammoth: The science of de-extinction by Beth Shapiro, Princeton University Press, \$24.95/£16.95

This is big biology too, but big in the

most literal sense. Beth Shapiro's "how-to" manual couldn't be more timely given the news that mammoth genes were cloned in living elephant cells earlier this year. She lobs a few ethical grenades too: where will the new beasts live? Why do it at all? That's easy – everyone loves mammoths and the idea of de-extinction.

5 Beyond Words: What animals think and feel by Carl Safina, Henry Holt, \$32/£20

If you like your animals living rather than re-created, then *Beyond Words* challenges you to rethink how we relate to Earth's other creatures. It is a fresh report from the field, detailing what animals do, how they are studied in the wild, and what it "feels" like to be them. This is essential reading for a deeper understanding of life and cognition on Earth.

6 The Man Who Wasn't There: Investigations into the strange new science of the self by Anil Ananthaswamy, Dutton, \$26.95

Some people think that they are dead, others that their limbs are alien, and still others that they have a doppelgänger. This world is far from the one in which we sit comfortably within our bodies, taking a sense of self for granted. Anil

"Why clone mammoths at all? That's easy – everyone loves mammoths and the idea of de-extinction"

Ananthaswamy, a consultant for *New Scientist*, looks at how a brain trying to make predictive sense of conflicting internal and external signals tells us a lot about "maladies of the self". An excellent if unnerving book: "you" turn out to be more fluid than "you" thought.

7 How to See the World by Nicholas Mirzoeff, Pelican, £8.99

In our fluid world, we need reminding how strange our visual culture has become. Artist John Berger did that job for the 1970s with his classic book *Ways of Seeing*; now Nicholas Mirzoeff teaches us how to "read" an astronaut's 2012 space-walk selfie – and how to decode military photos smothered with labels that claim to show weapons we cannot in fact see.

8 The Future of the Professions: How technology will transform the work of human experts by Richard Susskind and Daniel Susskind, Oxford University Press, £18.99

The latest in a slew of accounts of an automated future, in which machine learning algorithms stalk the land, human values are optional and Big Data has replaced Big Brother. The Susskinds, a father and son team, take on the "transformation" of the professions. What they see is doctors, teachers and lawyers becoming guides-on-the-side rather than sages-on-the-stage. But they would prefer a type of commons where our collective knowledge and experience "is nurtured and shared without commercial gain".

9 The Age of Sustainable Development by Jeffrey Sachs, Columbia University Press, \$34.95/£23.95

With the Paris climate talks a few hours away, it's worth remembering the clear agenda laid out by guru of sustainable development, Jeffrey Sachs. For him, it combines managing the planet so as not to destroy it for our children and understanding the world as a "complex interaction of economic, social, environmental and political systems", with an ethical view that ensures the well-being of its citizens. Optimistic – heroic even – but will it be enough? ■



ADAM HIRONS/MILLENNIUM IMAGES/UK



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For more information and to submit your applications /nominations before 18th December 2015 please visit

www.thekennelclub.org.uk/ICHA



Gresham Professor of Geometry

For over 400 years Gresham College has provided free public lectures, seminars and conferences in the City of London. Applications are now invited for the post of Gresham Professor of Geometry, that is, the mathematical sciences. The current incumbent is Professor Raymond Flood, whose term of appointment is nearing its end. Applications are invited from those with expertise in mathematics or the mathematical sciences, statistics, or the history of mathematics.

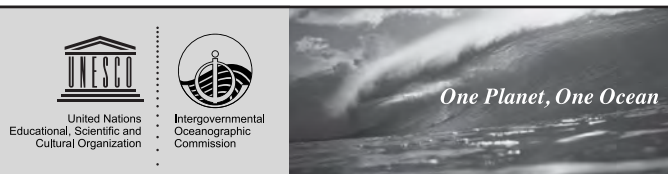
The appointment is part-time from 1 August 2016 and normally for three years. Gresham Professors must present six one-hour lectures each academic year. Attendance at Academic Board meetings four times per year and some social events is also expected. Gresham lectures attract large audiences and are recorded, archived and made available through the internet, so candidates should have an interest in communicating their subject to a wide audience. An annual fee of £6,900 will be paid by the College.

Further information about this position is available on the Gresham Website at: www.gresham.ac.uk/Geometry

Informal discussion may take place with the Academic Registrar, Dr Valerie Shrimplin, Gresham College, Barnard's Inn Hall, Holborn, London EC1N 2HH, Telephone 020 7831 0575, v.shrimplin@gresham.ac.uk

The closing date for application is 14 January 2016.

Interviews will be held in London on 29 February 2016.



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Head, Ocean Science Section Intergovernmental Oceanographic Commission of UNESCO

UNESCO is known as the "intellectual" agency of the United Nations. It is a key player in the global effort to build sustainable future for our planet. The Intergovernmental Oceanographic Commission (IOC) of UNESCO is the only specialized body in the UN system for ocean science, observations, services, and related capacity development.

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We look for a specialist in oceanography, marine biogeochemistry, ecosystems dynamics or climate change. You should bring with you strong analytical, organisational and partnership-building skills, proven leadership ability and an excellent command of English and French. High academic distinctions, a record of specialist publications would be an advantage, as would be your knowledge of other official UNESCO languages (Spanish, Russian, Chinese and Arabic).

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IMMUNOCORE

targeting T cell receptors

Milton Park, Oxfordshire



About Immunocore

Immunocore Limited, just south of Oxford, U.K., is an innovative and dynamic biotechnology company developing a platform of T cell antigen receptor-based therapeutics as a novel class of treatments for cancer and other diseases. Having entered into four major partnerships (Genentech, GlaxoSmithKline, MedImmune and Eli Lilly) and with our clinical candidate showing promise and a pipeline of TCRs, we are seeking to fill positions:

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We are looking for a **Senior Development Scientist**, with proficiency in recombinant protein or antibody characterisation, to perform characterisation of recombinant proteins (ImmTACs) to support lead candidate selection, sequence design, process development, stability and establishment of reference standards for early phase clinical trials.

Key responsibilities:

- Characterisation of post-translational modifications; sequence identification of purified recombinant proteins by peptide mapping (LC-MS/MS) and intact mass spectrometry, including experimental design, sample preparation, mass spectrometric analysis, and data interpretation;
- Analysis of new products, confirming/identifying their sequence, post translational modifications, chemical degradations occurring during forced degradation studies;
- Analysis of process intermediates, identification of impurities and drug product characterisation;
- Directing studies, writing reports, communicating results internally and externally.

Essential:

- Hands-on expertise of peptide mapping LC-MS/MS and intact MS including data interpretation;
- Excellent communication skills; ability to work to tight deadlines.

Desirable:

- PhD in a relevant discipline; background in recombinant protein or antibody characterisation, with 2 or more years' experience gained in industry;
- Experience with other HPLC/UPLC (size exclusion, ion exchange) and electrophoretic techniques.

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EDITOR'S PICK



Many histories of a water molecule

From Robert Worden

You tell the life story of a water molecule from a comet to the present day far too simply (14 November, p 31). There is in fact no such thing as the history of a single water molecule. We know from quantum mechanics that every time two water molecules collide in the ocean - one going left and the other going right - there is no true account of which one went left and which one went right. In colliding, they become a mixture and lose their identity - inasmuch as they ever had one.

So a water molecule in the full stop of your journal does not have one history. Through its previous collisions, it has 2, 4, 8, 16... and many more histories - the same huge set of histories as almost every other water molecule on the planet. A water molecule in my body did not pass through just one dinosaur. It passed through every dinosaur that ever had a bodily function.

Sutton, Cambridgeshire, UK

The editor writes:

■ A quantum mechanical view might even claim the world divides at each collision, in which case we are back to one story for the water molecule. We decided to avoid that minefield and stuck to a purely classical description.

To read more letters, visit newscientist.com/letters

Farmers' care for healthy soil

From Anna Butcher

Soils are under threat (10 October, p 43), but most farmers recognise that they are their most valuable asset and in Western Australia we take steps to keep our soils in balance. These measures include "knife point" technology to place seeds with minimal soil disturbance, retaining unused parts of harvested crops and planting legumes in continuous cropping systems. So many farmers are adapting to the challenges presented by drought and unpredictable climate.

We have adopted a new pasture legume on our farms to enrich the soil with nitrogen. *Serradella* has an extensive root system, grows on many soil types and is tolerant of acid soils. No artificial nitrogen is used on cereal cropped with *Serradella* and this has not had a negative impact on yields. The plant can have organic nitrogen "on demand" from the soil, when it needs it.

Farmers are part of the solution, not just part of the problem. Brookton, Western Australia

Quantum snake oil and security flaws

From Lawrence D'Oliveiro

There has been a lot of hype about quantum computing over the years, including claims that quantum cryptography will offer better security (17 October, p 10). This comes from a fundamental misunderstanding of how cryptography works.

Our current cryptographic algorithms are already strong enough. The main weaknesses in computer system security come from mistakes in implementing the algorithms - for example, weaknesses in key management and authentication - and from sources of random numbers that

are in practice not so random. Quantum cryptography addresses neither of these concerns.

Quantum processes are theoretically random. But you cannot guarantee that this randomness remains untainted on its way into the upper levels of your systems. Another claim is that quantum channels are proof against eavesdropping, or allow it to be detected. But I see this as in fact a weakness. Quantum channels, being so sensitive to the slightest interference, will likely become prone to "quantum denial of service" attacks (QDoS?), in which malicious parties introduce a few random extra interactions to make it look like an eavesdropping attack is under way. As with the boy who cried "wolf", if the alarm goes off enough times, the guards stop paying attention to it. Hamilton, New Zealand

They don't like to be beside the sea

From William Kirby

Given the potential for a catastrophic rise in sea levels in the next 20 years if the West Antarctic ice sheet collapses (17 October, p 8), surely the UK government should be seeking to decommission coastal nuclear power stations rather than building more? Horsham, West Sussex, UK

Design is the root of progress

From Bill Summers

Your Leader articles make the case for not reducing national science budgets (14 November, p 5). But it is a poor case if considered as a stand-alone issue. Science is about taking things apart to understand them; and design is about putting them back together to make a useful object. Science serves no

practical purpose unless it leads to a design, and design without science is just good taste.

Buckminster Fuller's concept of design/science is a worthy one. He said that all of human progress is determined by our ability to "do more with less". An example of this is in the design history of the radio valve, transistor and microchip. All are gates through which an electrical signal passes in one direction, but progressively more effectively.

Science needs to be seen as the research part of the design method continuum. This starts by stating a brief, then doing scientific research, creating and constructing the design and finally gaining feedback. This is a circular rather than a linear process. The research may lead to a new brief or new design. Sturminster Newton, Dorset, UK

Making the best of appalling events

From Meredith Lloyd-Evans

I was inspired by your interview with face transplant recipient Carmen Blandin Tarleton (31 October, p 28). It offers a real example of determination to make the best of appalling events.

Well done on printing this challenging article. I have tremendous admiration for Blandin Tarleton. Cambridge, UK

Brain stimulation and dopamine

From Bijal Shah

I note that side effects of deep brain stimulation therapy to treat Parkinson's include impulse control disorders such as excessive gambling and hypersexuality (24 October, p 38). These symptoms are similar to side effects reported for the main dopamine analogue drugs. Is it

“Great! I would feel safer if I was diagnosed by a pigeon... not a specialist...”

Sylvie Tapp is not entirely reassured at pigeons being taught to diagnose breast cancer on X-rays (21 November, p 12).

possible that this therapy causes the brain to release dopamine, possibly from underactive or dormant neurons?

Slough, Berkshire, UK

A bigger issue than messing up Mars

From Leopold Faltin

I fully understand Jeff Hecht's call for caution over crewed space missions that might contaminate Mars with terrestrial microbes (7 November, p 26). However, although a robotic sample-return mission would help to avoid this particular problem, won't it just create another? Wouldn't it still run the risk of contaminating Earth with microbes from Mars, if any exist? Samples of Martian soil could certainly be sealed off properly to avoid contamination, but what about the tools and other parts of the robotic probe in contact with Martian soil?

I wonder how this risk to Earth's biosphere could be reasonably minimised.
Vienna, Austria

Ancient caving in the dark

From Anthony Donaldson

Donald McCoy interprets the *Homo naledi* finds deep inside a cave system as implying early mastery of fire, to light the way (Letters, 31 October). A simpler explanation might come from a few people, blind from early in life, learning to navigate by echolocation. A Wikipedia entry reports one person demonstrating his skill in a cave. Could such people help us investigate the possibility that echolocation skills were culturally transmitted among early hominins?
Nottingham, UK

There is also a darker future...

From John Thomas

A basic income for all seems to be a widely assumed scenario for the future, according to Laura Smith (3 October, p 28), and Anil Ananthaswamy in his review of

The Master Algorithm (31 October, p 44). I don't see much about darker futures which seem at least as likely.

In these the “haves” may just pull up their drawbridges, using robots to supply their every need, including fending off the starving, unemployed masses living on reservations. I know this will not be a popular scenario, and it's certainly not a desirable one, but the idea that the elite would allow governments to take away 90 per cent of their resources in order to give the other 99 per cent a comfortable life seems pretty unrealistic to me.

Kirknewton, West Lothian, UK

The internet in an older box than that

From Simon Mallett

Your recent article about the ability to take a snapshot of part of the web and access it as a “web in a box” away from any internet connections (26 September, p 22) took me back to 1997 in Pakistan. The British Council's plans to

celebrate the 50th anniversary of independence were well filled with arts and culture, but lacked any technology contribution.

Pakistan then had very limited internet access. I proposed setting up copies of some of the major UK websites on servers in British Council libraries in Islamabad, Lahore and Karachi, so they could be accessed both locally and by dial-up modem.

I was allocated 5 minutes to demonstrate this to the prime minister John Major. He had to be dragged away to meet the press; I thus gained my 15 minutes of fame when he opened the “Britain on Line” project.
Lenham, Kent, UK

An Ig Nobel with a practical point

From Andrew Brooker

Bill Corner suggests that discovering the typical duration of mammalian urination may not just be worthy of an Ig Nobel prize but actually a useful diagnostic tool for men with prostate problems (Letters, 31 October). This sounds eminently simple and sensible, so I'm planning a smartphone app and associated gadget (on the lines of a heart rate wristwatch monitor), possibly to be called an iP.

Dursley, Gloucestershire, UK

For the record

■ That stings: the water corals inhabit is more acidic than it was, but is still alkaline (14 November, p 17).

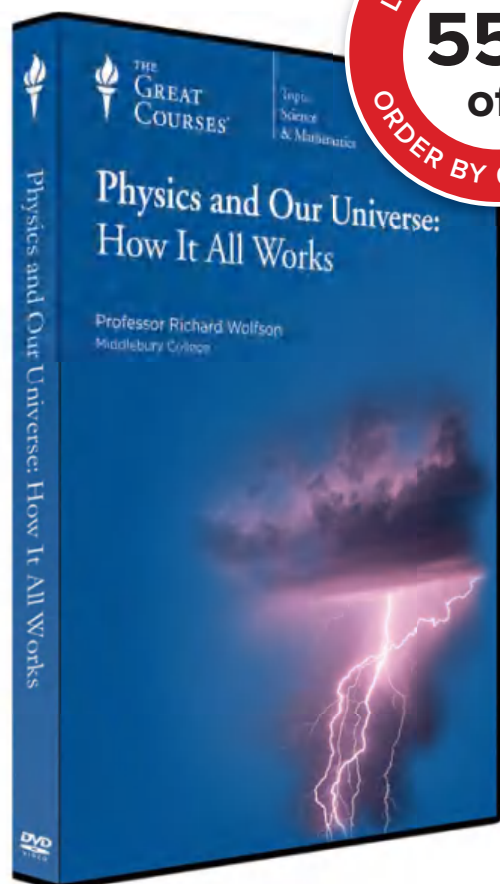
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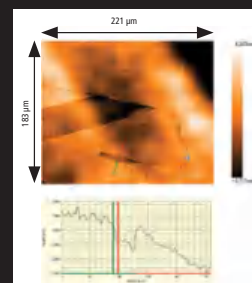


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EAU de deterrent, anyone? Fears about chemical nasties have consumers turning their noses up at mosquito repellents containing DEET in favour of “natural” alternatives such as citronella and vitamin B patches.

Stacy Rodriguez and her colleagues decided to look at how effective these alternative repellents were, publishing their results in the *Journal of Insect Science*, including two perfumes as comparators.

In tests conducted with live mosquitoes, many of the natural repellents had a negligible effect, but one concoction showed promise: Victoria’s Secret Bombshell perfume, which the manufacturers note is of a “fruity floral” type, including “purple passion fruit, Shangri-la peony and vanilla orchid”.

The authors report that the pink-bottled fragrance “has shown to be a strong repellent with effects lasting longer than 120 minutes” – admirable efficacy, but Feedback suspects probably not what the manufacturers were aiming for.

HE WAS the dog that defied science. Ringo, a golden retriever specially bred to inherit a genetic mutation that causes severe muscular dystrophy, surprised scientists by exhibiting none of the symptoms of the disease.

Instead, Ringo was left feeling so sparky he sired a number of pups with his labmates, one of which also escaped symptoms of the disease, reports *Nature*.

Tests revealed that Ringo had a second mutation which rendered him immune to the effects of the first, offering new avenues of research against human forms of the disease. Though perhaps science-defying animals are not the most useful research models.

FIRE somewhat indiscriminately in their heyday, wartime Germany’s V2 rockets continue to suffer from questionable accuracy. Kevin Lee reads in a popular history book that the weapons flew at “about 5600 km/h (3479.5 mph).”

“Leaving aside the fact that the maximum velocity was somewhat variable anyway,” he writes, “is it not agreed that a conversion cannot go from two significant figures to five?” Feedback doesn’t feel qualified to answer: this is, after all, rocket science.

MORE dubious accuracy: Fred Nind reports that his local Vue cineplex in Aberdeen boasts that it is a “7 screen cinema with approximately 1,531 seats”.

“I guess that is because they round partial seats up or down to make whole ones,” says Fred. Feedback wonders if it depends on how many Aberdonians can squeeze themselves into a single cushion – a cunning way to cut the price of admission in these austere times, perhaps?

BREVITY may be the soul of wit, but what language style do fraudsters employ? That question is pondered by David Markowitz and Jeffrey Hancock in “Linguistic Obfuscation in Fraudulent Science”, a study which examines 253 papers retracted for fraudulent content to see if they share any grammatical characteristics.

Their findings, published in the *Journal of Language and Social Psychology*, reveal that fraudulent papers showed a higher use of obfuscating language, hinting that the authors were relying on jargon, low readability and a surplus of references to hide their deceit.

However, the difference was small, and not distinctive enough to separate fraudulent papers from genuine ones. Shockingly, it appears that even honest science papers are often written in an opaque and unreadable fashion. Feedback is lost for words.

LIEGH White writes to remind us that we cannot escape nominative determinism. Liegh points to the example lying right under our own noses: “Who else could co-chair the committee to scrutinise the Misuse of Drugs Act other than an MP called ‘Amess’?” (14 November).

SETTING a low bar: Nestlé claims to be “building healthy lives” with its Pure Life spring water, according to a flyer passed on by Julia Pallanca.

Few would argue that drinking water in moderation could be anything but good for you, but in case someone did, the advert justifies itself in the small print: “Water contributes to the maintenance of normal cognitive function.” Feedback reports that having sampled a glass of the wet stuff, our cognitive functions are indeed functioning normally.

FINANCIAL investigator Faire Sans Dire has been looking into who runs the UK’s businesses. A Freedom Of Information request to Companies House, where the details of all UK firms are registered, reveals 315 incredibly busy directors who were named as overseeing more than 100 companies each.

But even more hard-working staff can be found: records at the government office show there are



319 directors aged over 100, one of whom is an improbable 945 years old.

“Just imagine the benefits of having the wisdom of a 945-year-old at your board meeting,” says Faire Sans Dire chairman Bill Fairclough. Feedback can indeed imagine them, but we’re arming ourselves with garlic and stakes all the same.

“The selected garment is restricted in the number of copies produced, although in fact the number may be very low or very high” – Pull & Bear defines ‘limited edition’ for Mike Barsham

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week’s and past Feedbacks can be seen on our website.

Air drumming

When I open my car windows while driving, everyone inside can hear a helicopter-like thumping sound. It is even worse when the rear windows are opened and it gets louder at higher speeds. What causes this phenomenon?

■ An open sunroof or window essentially acts as an acoustics phenomenon known as the Helmholtz resonator. The most common example of this is the sound created when you blow across the top of an empty bottle. The pressure inside the car resonates according to the cross-section of the opening, the speed of the air over it and the volume of the cavity inside.

These changes in pressure are perceived as a drumming sound. Imagine that the air inside and outside the car are separated by a thin invisible membrane. If something were to push down on the membrane and let go, the membrane would spring up and down, with the amplitude of the oscillations getting smaller, as with an elastic band.

But what if a downward push arrived just as the membrane was already moving downwards? This is where vortices come into play. They create resonance, maximising the amplitude, by pushing down and increasing the pressure in the car just as the imaginary membrane is moving downwards anyway.

This is similar to the way that people time their push on a

child's swing. You push hard just as the swing is starting to move downwards again to get maximum thrust.

The resonant frequency is shifted higher for bigger openings and smaller volumes and vice versa. So blowing across a half-empty bottle should generate a higher frequency than blowing across an empty one.

Mike Follows

Sutton Coldfield, West Midlands, UK

Drying dilemma

Which method of drying my hands uses less energy: an electric blow-dryer or a paper towel made of dried wood pulp?

■ This depends on how the energy cost is measured. The effort of grabbing a tissue and wiping is less than it takes to generate a several-hundred-watt blast of hot, germ-y air in which to rub your hands interminably.

However, the energy expenditure of producing and recycling the paper is more difficult to assess. Wood had to be grown, it had to be harvested, transported, shredded, pulped, matted, dried, configured into saleable and usable formats and packaged. After use, a recycling plant had to re-pulp the material and repeat much of the cycle, which only in ideal circumstances is cheaper than producing new paper.

Then again, how much energy did it take to manufacture the

blower and ultimately to recycle it? How large a pile of consumed paper would the device have to eliminate to justify its role as an implement of conservation?

Perhaps it would be best to carry your own hand towel, or simply to dry your hands on your trouser legs. Towelling pads sewn onto clothing could become a conservation-conscious fashion statement to rival the breast-pocket handkerchief.

Jon Richfield

Somerset West, South Africa

Head space

My thoughts feel as though they are in my head. Is there a physical basis for this, or is it just that I know that's where my brain is?

■ Your head is the focus for receiving information from your environment, mainly through sight and sound. Thought is secondary to sensory perception, but both have to combine quickly when you are threatened, and evolution has sited the organs for sensing information and processing it close together to ensure speedy response to dangers such as sabre-toothed tigers and muggers.

Researchers at the Karolinska Institute in Stockholm, Sweden, investigated out-of-body illusions using a brain scanner. They found that the brain's posterior cingulate cortex combines the feelings of where the self is located with that of body ownership. This

is why you feel as if your thoughts are inside your head.

Sensory deprivation can cause such feelings to be lost. When people lose sensory awareness while they are still conscious,

"When people lose sensory awareness while conscious they may experience out-of-body sensations"

they become disorientated and may experience out-of-body sensations, feeling as though their thoughts are no longer inside their head. This can occur during certain types of torture or can be self-induced through meditation or drug use.

David Muir

*Science department
Portobello High School
Edinburgh, UK*

This week's questions

LIQUID GOLD

I recently saw vodka in the supermarket with real gold leaf flakes in it. What caught my eye was that the gold flakes were distributed uniformly throughout the bottle. Gold is much denser than water, so why don't they sink to the bottom?

Andrew Menadue

By email, no address supplied

DYING LIGHT

Does the sky ever end?

Sabine (aged 5)

Plettenberg Bay, South Africa

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